A STUDY ON BOWEL WALL HEMORRHAGE AND ITS CORRELATION WITH THE ANTEMORTEM HANGING

Dissertation submitted in partial fulfillment
of the requirements for the degree

M.D. (Forensic Medicine)
BRANCH - XIV

INSTITUTE OF FORENSIC MEDICINE
MADRAS MEDICAL COLLEGE
CHENNAI – 600 003

THE TAMIL NADU
Dr. M.G.R. MEDICAL UNIVERSITY
CHENNAI

APRIL 2015

BONAFIDE CERTIFICATE

This is to certify that the work embodied in this dissertation entitled **"BOWEL WALL HEMORRHAGE AND ITS CORRELATION WITH THE ANTEMORTEM HANGING"** has been carried out by **Dr. KAMALAKANNAN G, M.B.B.S,** a Post Graduate student in Institute of forensic medicine, Madras medical college, Chennai-3, under my supervision and guidance for his study leading to Branch XIV M.D. Degree in Forensic Medicine during the period of April 2014 to September 2014.

Dr. R. VIMALA M.D
Dean
Madras Medical College &
Government General Hospital,
Chennai – 600 003.

Dr. R. VALLINAYAGAM,
Director and Professor,
Institute of Forensic Medicine,
Madras Medical College &
Government General Hospital
Chennai – 600 003.

Date:

Place: Chennai

DECLARATION

I, **Dr. KAMALAKANNAN. G, hereby declare** that this dissertation entitled "**BOWEL WALL HEMORRHAGE AND ITS CORRELATION WITH THE ANTEMORTEM HANGING**" is a bonafide work done by me as a postgraduate student of **the Institute of Forensic Medicine,** Madras Medical College and Rajiv Gandhi Govt. General Hospital, Chennai-3, under the expert guidance and supervision of **Dr. R. VALLINAYAGAM, M.D.,**Director &Professor, Institute of Forensic Medicine,Madras Medical College and Rajiv Gandhi Govt. General Hospital, Chennai-3.

This Dissertation is submitted to the Tamil Nadu Dr.M.G.R. Medical University in partial fulfillment of the requirements for the degree of M.D. FORENSIC MEDICINE (Branch XIV). It had not been submitted to any other university or institution for the award of any degree or diploma.

Place: Chennai-3 Signature of the scholar

Date: **(Dr. KAMALAKANNAN. G)**

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INSTITUTIONAL ETHICS COMMITTEE
MADRAS MEDICAL COLLEGE, CHENNAI-3

EC Reg No.ECR/270/Inst./TN/2013
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CERTIFICATE OF APPROVAL

To

Dr.G.Kamalakannan,
Postgraduate
Institute of Forensic Medicine,
Madras Medical College, Chennai-3.

Dear **Dr.G.Kamalakannan,**

The Institutional Ethics Committee of Madras Medical College, reviewed and discussed your application for approval of the proposal entitled **"Bowel wall haemorrhage and its correlation with the antemortem hanging"** No.10042014.

The following members of Ethics Committee were present in the meeting held on 08.04.2014 conducted at Madras Medical College, Chennai-3.

1.	Dr. C.Rajendran, M.D,	-- Chairperson
2.	Prof. Kalaiselvi, M.D, Vice Principal, MMC, Ch-3	-- Member Secretary
3.	Prof. Nandhini, M.D, Inst. of Pharmacology, MMC, Ch-3	-- Member
4.	Prof.Bhavani Sankar, M.S, Prof & HOD General Surgery, MMC, Ch-3	-- Member
5.	Prof.V.Padmavathi, M.D, I/c. Director of Pathology, MMC, Ch-3	-- Member
6.	Thiru. S. Govindasamy, BA., BL	-- Lawyer
7.	Tmt.Arnold Saulina, MA MSW	-- Social Scientist
8.	Thiru.S.Ramesh Kumar, Administrative Officer, MMC, Ch-3.	-- Lay Person

We approve the proposal to be conducted in its presented form.

Sd/Chairman & Other Members

The Institutional Ethics Committee expects to be informed about the progress of the study, and SAE occurring in the course of the study, any changes in the protocol and patients information / informed consent and asks to be provided a copy of the final report.

21/4/14

Member Secretary, Ethics Committee

MEMBER SECRETARY
INSTITUTIONAL ETHICS COMMITTEE
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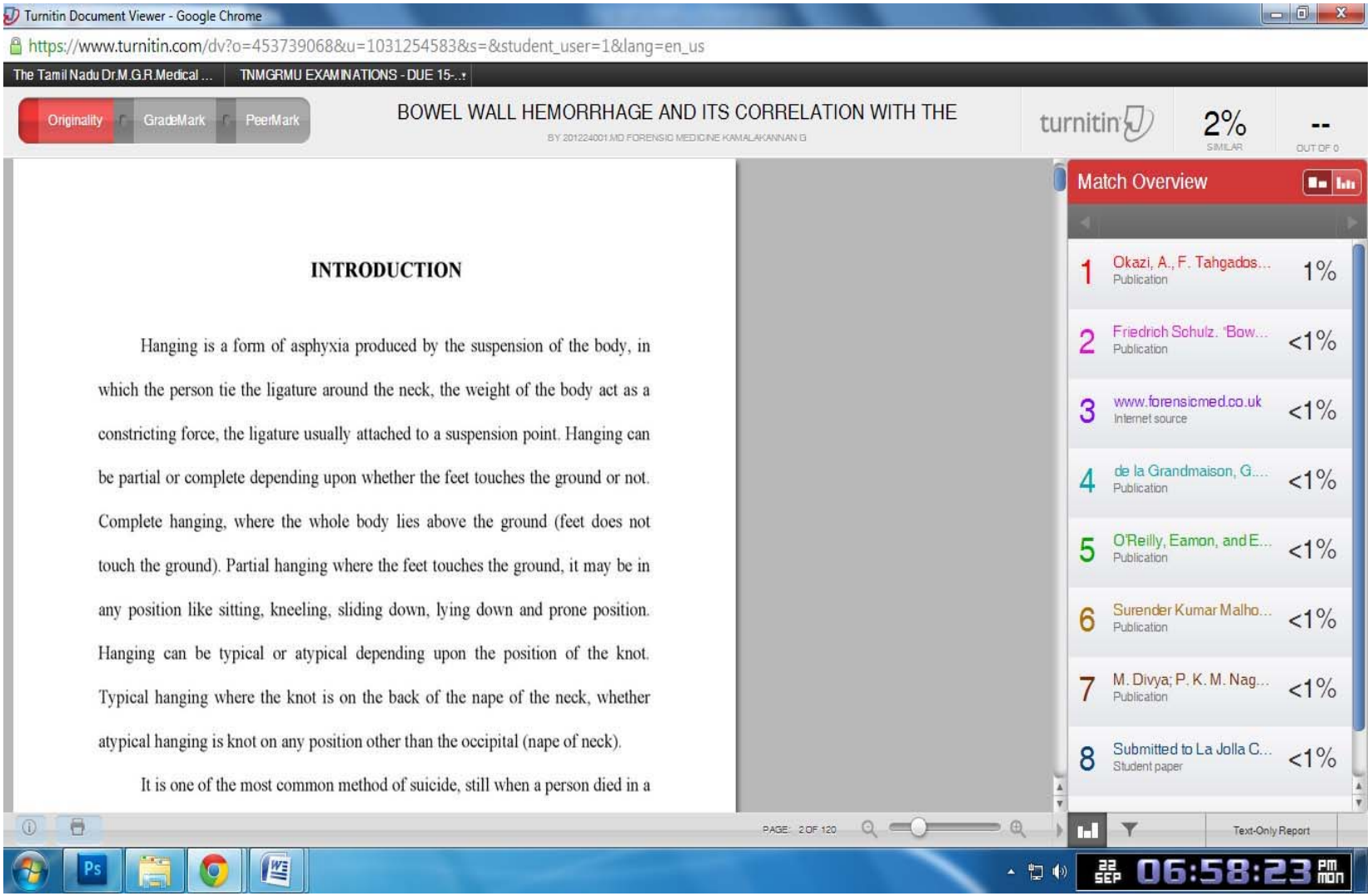
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INTRODUCTION
Hanging is a form of asphyxia produced by the suspension of the body, in which the person tie the ligature around the neck, the weight of the body act as a constricting force, the ligature usually attached to a suspension point. Hanging can be partial or complete depending upon whether the feet touches the ground or not. Complete hanging, where the whole body lies above the ground (feet does not touch the ground). Partial hanging where the feet touches the ground, it may be in any position like sitting, kneeling, sliding down, lying down and prone position. Hanging can be typical or atypical depending upon the position of the knot. Typical hanging where the knot is on the back of the nape of the neck, whether atypical hanging is knot on any position other than the occipital (nape of neck).
It is one of the most common method of suicide, still when a person died in a
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INTRODUCTION

Hanging is a form of asphyxia produced by the suspension of the body, in which the person tie the ligature around the neck, the weight of the body act as a constricting force, the ligature usually attached to a suspension point. Hanging can be partial or complete depending upon whether the feet touches the ground or not. Complete hanging, where the whole body lies above the ground (feet does not touch the ground). Partial hanging where the feet touches the ground, it may be in any position like sitting, kneeling, sliding down, lying down and prone position. Hanging can be typical or atypical depending upon the position of the knot. Typical hanging where the knot is on the back of the (nape of) the neck, whereas atypical hanging is knot on any position other than the occipital (nape of neck) region.

It is one of the most common method of suicide, still when a person died in a position of hanging it always rises a doubt whether it was suicidal or homicidal in nature, where the accused wants to hide the evidence and mimic it as a suicidal one. Hanging in general suicidal still has to prove it by other physical evidence it is not homicidal in nature[1].So it is necessary to prove the manner of hanging in all cases where the corpse was hanged. There are many vital events to prove the nature of hanging but still no one is the definite sign of ante mortem hanging.

BOWEL WALL HEMORRHAGE AND ITS CORRELATION WITH THE ANTEMORTEM HANGING

ABSTRACT:

Bowel wall haemorrhage is one of the vital sign to say the hanging is antemortem in nature. This is a rare study, only few authors were commented about bowel wall haemorrhage in antemortem hanging. This is a prospective study carried out to find the frequency of bowel wall haemorrhage in medico legal autopsy done at mortuary of madras medical college, Chennai. All cases with the history of hanging are subjected to autopsy. The cases which are diagnosed or having history of acquired or congenital bleeding disorder, DIC, sepsis, mechanical trauma to the abdomen, chronic intestinal diseases, severely decomposed body are excluded from the study. All the relevant data to my study are collected from the investigating officers. After completing the external examination, internal dissection was carried out. Autopsy were performed focused to identify the all the findings relevant to hanging including bowel wall haemorrhage. The presence of bowel wall haemorrhage is confirmed by histology. This study was conducted among 38 cases.The frequency of bowel wall haemorrhage were calculated using chi-square test. 26.3% of the study showed bowel wall haemorrhage. All the relevant data which are considered as sign of antemortem hanging are analysed with the bowel wall haemorrhage. From this study we come to a conclusion after excluding all the possible cause

of bowel wall haemorrhage, the presence of bowel wall haemorrhage is considered as a one of the important vital sign of antemortem hanging. Bowel wall haemorrhage add more value to the antemortem hanging along with other signs of hanging.

Keywords:

Antemortem Hanging, Bowel Wall Haemorrhage, DIC, Clotting Disorder, Decomposition, Histology.

There are many vital signs, the local signs include the injury to the laryngeal soft tissues and laryngeal framework, injury around the subcutaneous soft tissues, injuries around the ligature mark i.e., areas of minimal bleeding around the ligature mark. The systemic signs include congestion of head and neck region, histomorphological analysis of lung tissues. The indirect evidence to say it as antemortem hanging is Simon's bleeding[2] i.e., bleeding into the anterior aspect of the intervertebral discs mainly involving the lumbar vertebrae, a positive phosphatide sample[3], pulmonary microembolism syndrome[4], pulmonary dystelectasis, sometimes signs of aspiration[5, 6], however no one is specific[7, 8, 9], for antemortem in nature, some of them may be post mortem[10] in nature. So it is necessary to add all the vital events to prove the hanging as antemortem in nature.

The **bowel wall hemorrhage** is one of the vital signs to prove it as antemortem in nature if other vital signs could be absent. Though bowel wall hemorrhage is not present in all cases of hanging, if it is present then the result will be more favor of the antemortem nature. If the agonal period gets prolonged then there will be bowel wall hemorrhage and hemorrhage on to the anterior aspect of the intervertebral disc named as "Simon's bleeding". After the compression of the neck structures, there will be definite blood flow to the abdominal viscera. 28 percent of the stroke volume is maintained for the visceral perfusion. There will be increased pressure gradient between the

artery and vein in the ratio of 1:10 resulting in the post capillary congestion leads to bowel wall hemorrhage. The mechanism for bowel wall hemorrhage can also be explained by the bowel wall spasms which occurs due to decoupled autonomic nervous system during the process of hanging. One more mechanism is the release of catecholamine which leads to the increased systemic hypertension with long pulse pressure which produces hemorrhage on the bowel wall. The above said mechanism is possible only when there is long agonal phase, because then only there will be enough time to produce these sign.

Though many signs are there in antemortem hanging nothing is more specific, so we have to add all the evidences as possible, here we are adding one more sign to increase the specificity of the hanging to say it is ante mortem in nature that is bowel wall hemorrhage. So we are doing the study titled **"BOWEL WALL HEMORRHAGE AND ITS CORRELATION WITH THE ANTE MORTEM HANGING"**

In this study we estimated the incidence of bowel wall hemorrhage and analyzed the areas most commonly involved on the whole bowel including small bowel and large bowel, the presence of bowel wall hemorrhage could be confirmed by the histopathological examination of the hemorrhagic areas. The tissue bits from the hemorrhagic areas along with the normal areas are analyzed histopathologically for the presence of hemorrhage. The bowel

hemorrhage correlated with the other antemortem findings of hanging, its presence analyzed with the various factors of deceased like age, sex, weight, duration of hanging, postmortem interval, systemic or local diseases they affected, correlation with the Simons bleeding, congestion of head and neck, petechial hemorrhages, type of hanging, admitted or not, ligature material used, type of knot, ligature mark, salivary dribbling, cyanosis.

Thus the bowel wall hemorrhage is not present in all cases of hanging but if it is present, it is an additional proof of antemortem hanging[11].

Aims & objectives

AIMS AND OBJECTIVES

1. To find the incidence of bowel wall hemorrhage in cases of hanging.

2. To correlate the presence of bowel wall hemorrhage with the antemortem hanging.

3. To correlate the presence of Simons bleeding with the bowel wall hemorrhage.

Review of literature

REVIEW OF LITERATURE

ANATOMY OF NECK:

Neck is the main area which comprises many vital structures which passes through it. Skin is the superficial layer, next to the skin is platysma which is the superficial muscle arises from the fascia which covers the sternocleidomastoid muscle. The external jugular vein lies superficial to the muscle. The sternocleidomastoid muscle has two heads sternal and clavicular head.

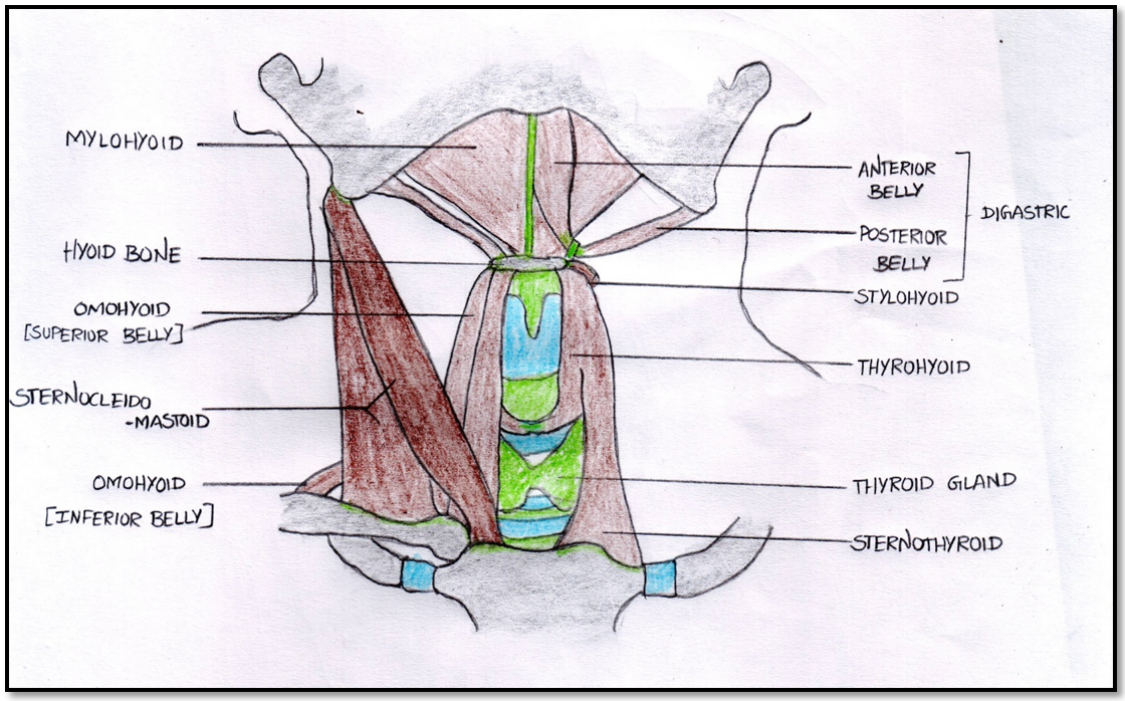

Fig 1.Showing neck muscles.

The internal jugular vein, vagus nerve and common carotid artery all the three structures enclosed in a carotid sheath along with cervical lymph nodes. The carotid lies medial and deep to the internal jugular vein, whereas the vagus nerve lies posterior to the above said two structures.

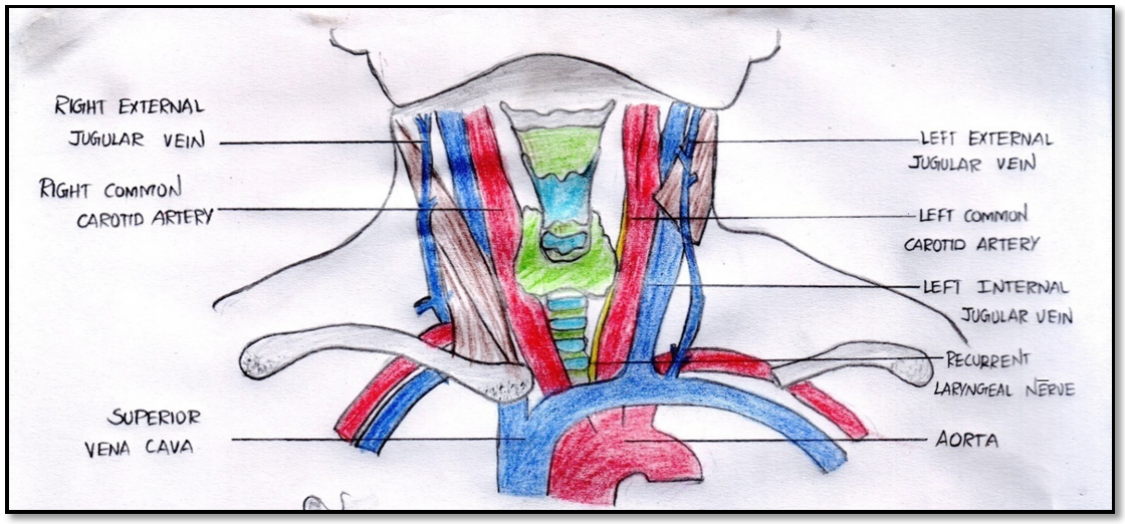

Fig 2. Vascular anatomy of the neck.

These structures passes beneath the muscle layer. The carotid sinus lies at the starting of bifurcation of the common carotid artery at the initial point of internal carotid artery which is innervated by the glossopharyngeal nerve (carotid sinus nerve). The carotid sinus act as a baroreceptor or pressoreceptor which reacts to the change in the arterial blood pressure. The carotid body a small tissue or bit of mass present on the medial side of the bifurcation of the common carotid near to the sinus supplied by the carotid sinus nerve. It act as chemoreceptor which sense the low level of oxygen in the blood, accordingly as a reflex it alters the rate of respiration, heart rate, increases blood pressure.

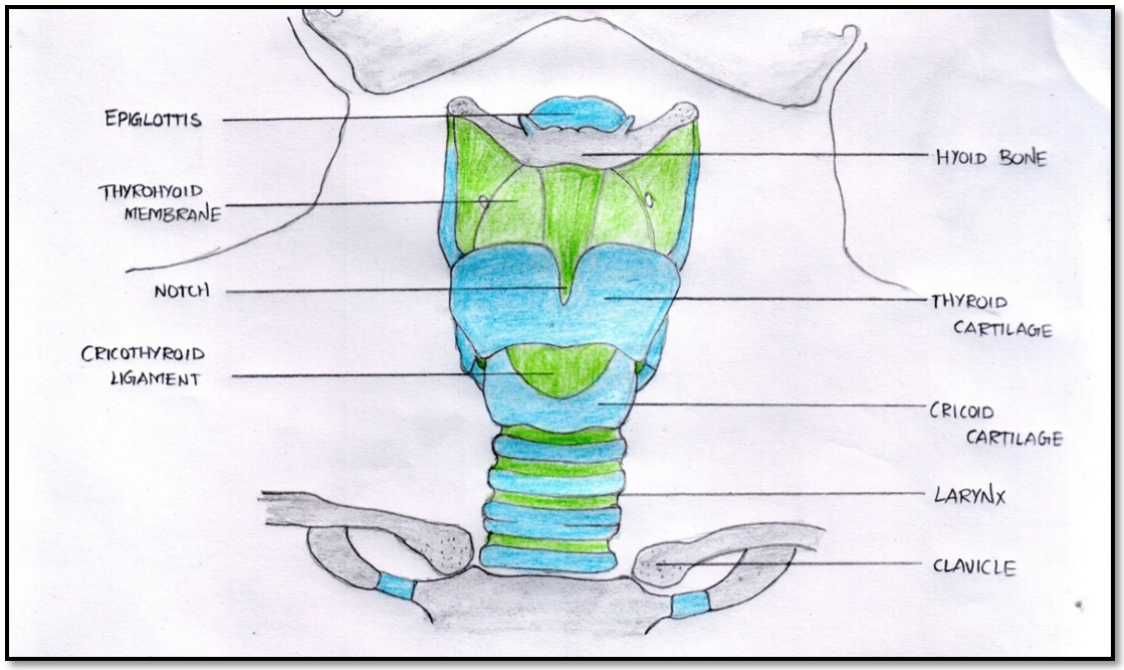

Fig 3. Cartilages of the neck.

The common carotid divides into internal and external in which internal carotid has no branch in the neck, which carries the blood to the cranium and give its branches directly inside the cranium. The external carotid artery gives its branches in the neck which supplies the neck structures.The hyoid bone lies at high level in the neck which is connected to the thyroid cartilage by the thyrohyoid ligament. The thyroid cartilage lies at the level of c5 to c7, below it is cricoid cartilage which is circular morphologically. The above two cartilages are connected by the cricothyroid membrane. The tracheal cartilage starts next to the cricoid cartilage.

BOWEL WALL ANATOMY:

Bowel wall is a tubular structure, which is made up of four layers namely mucosa, sub mucosa, muscularis, and serosa. Mucosa is the inner most layer and serosa is the outer most layer. Bowel wall include small bowel which starts from duodenum proximally and ends at jejunum, large bowel starts at ileoceacal valve and ends at anal sigmoid colon. Small bowel is around 6 meter in length and the large bowel is around 1.5 to 2 meter in length.

Starting from the distal part of the duodenum to the proximal two thirds of the transverse colon is supplied by the superior mesenteric artery and its branches. The remaining part of the colon is having its blood supply from the inferior mesenteric vessel and its branches. Middle and inferior rectal artery together supplies the anal canal which are the branches of internal iliac arteries. The vessels form a network and supply each layer separately, that is they form plexus like mucosal plexus, sub mucosal plexus, inter muscularis plexus, and sub serosal plexus. The arterial network enters the serosa, muscularis then pass through the sub mucosa. They form large plexus which break into capillary networks that surrounds and supplies the areas around the network.

Venous return follow the same arterial distribution, superior and inferior mesenteric joined together to form splenic vein which drains in to the portal vein. The intestinal wall is supplied by the autonomic system in which, the

sympathetic and parasympathetic together constitutes the extrinsic nerve which is connected with the intrinsic nerves.

HANGING:

Hanging is a form of asphyxia produced by the suspension of the body, in which the person tie the ligature around the neck, the weight of the body act as a constricting force, the ligature usually attached to a suspension point.

EPIDEMIOLOGY:

It is one of the most commonly used method for committing suicide all over the world. In hanging the person will get unconsciousness within few seconds (15 seconds) and they think hanging will cause a painless death that is why most of them choose hanging as a suicidal method[12]. It is also most common method of suicide among the Asian population. Malaysia is one of the country where the other country people used to settle their life in the country for various reasons. The population strategy of Malaysia people is Malay 59 percent, Chinese 26 percent, Indians 8 percentage, and the remaining population constitutes foreign immigrants from Indonesia, Bangladesh, Vietnam and others. But the percentage of suicide among the population was more in Indians and Chinese when compared to the Malay people. In previous studies conducted by Nadesan also reported more cases of hanging among the Indians[13]. Similar study conducted in Singapore with different composition of people including 76.6 percent of Chinese, 15 percent of Malays and 6

percentage of Indians, in this study also suicidal cases using hanging was more among the Indians contributes 20.3 per 100,000, second leading among the Chinese contributes 14.3 per 100,000 and the Malays are the last, constitutes 2.1 per 100,000.

A similar study conducted in Saudi Arabia also showed the same results, as the Arabs people are outnumbered by the non-Arabs especially our Indians, Bangladeshis and Sri Lankans. They described in their study that the people who immigrate to the Saudi Arabia are using this method of suicide most commonly. The important feature is that most of them are Asians, the cultural, economic and religious factors are the important thing for the gross difference between the Asians and the other population. In certain communities the suicide or attempted suicide is consider as a disgrace to the particular person and to their entire family. In our communities because of the cultural background most of the people commit suicide using hanging[14]. Malays due to the religion fear and because of different culture, they commit suicide less often when compared to others.

In Canada[15] suicide is the first most commonly used method for committing suicide, in U.S. next to the firearms, hanging is the second commonest method, in U.K. study was conducted on 2001 which shows that hanging was the first most common method of committing suicide among the males and second most common method among the females next to poisoning.

Study conducted on Turkish statisticalinstitute from the period of 2002 to 2011 regarding the suicide the results showed both the sexes opt the hanging to commit suicide as a most common method[16].

In India, suicidal rate is disproportionately increasing in Kerala, most of them are young adult males, and most of them using soft material as a ligature material nearly 50 % using objects like sari, shawl, lunges[17]. As suicide is the impulse mediated act they can use any material which is nearby or easily available on that particular time[18]. It is not like that the two extremes of age cannot use hanging as a method of choice, **Polson Gee** reported about a case of suicidal hanging by a 10 year old child[19]. Most of the victim are adult males in the age group of 40 years and they have the history of drug addiction[20].

The marriage is not a protective factors in case of males and majority of the women are housewives. There is increasing in death by hanging among the married persons both men and women compared to the bachelor life. Now the incidence of suicidal hanging has been increasing among the females when compare to the past. Married women due to frustration, sexual problems, and problems in the new house not able to bear it and try to end their life. Still the proportion is higher on the male side after poisoning. All the cases of hanging should be considered as a suicidal one unless otherwise proved to be some other manner. According to the study which was conducted in Kerala smoking and alcoholism contributes to the most common cause for suicide, but

according to **Davidson** psychological problem was the most common cause for the suicide[21]. Commonly the persons are affected with personal problems like drug addiction, stress disorder, neurotic problems and family problems like poverty, love failure, frustration in daily life activities, not able to concentrate on studies. So still now the hanging is one of the commonest and easiest method of committing suicide next to poisoning.

According to **Byard et al 1994** most frequent cases of hanging in adults occurred as auto erotic accidental death, they are commonly sadomasochists, mostly they do the masturbation, exclusively males, who use the asphyxia combined with conditional sexual reflex to increase the period of orgasm and intensity of orgasm.

TYPES OF HANGING:

Depending upon the feet touches the ground or not it is classified into two types

1. Complete hanging
2. Partial hanging

In **complete hanging** the whole body including the feet doesn't touches the ground the suspension point will be usually at a higher level from the ground, they can use some objects to stand and tie the ligature at the suspension point at a higher level, usually they use the furniture which are

present in the room already[22]. In the scene of the crime the objects used for tie at suspension point will always be present, if it is not then it always raises a doubt of homicidal hanging. In case of complete hanging the whole body weight used as a force to constrict the neck structures, increase in body weight leads to increase in damage to the neck structures and also obstruction of the vessels, airway are due to the compression given by the ligature around the neck.

In **partial or incomplete hanging** the feet touches the ground, it may be in any position like sitting, kneeling, sliding the body down from the area of suspension point, lying down, and prone position. The suspension point will be usually at a lower lever when compared to the cases of complete hanging. It is not mandatory to whole body weight should be there to cause occlusion, the weight of the arms, chest are more than sufficient to cause the occlusion which causes death. Even cases have been noted, as old age people lying on the sofa with their neck on the arms of sofa found dead due to the compression given to the neck, is a type of partial hanging. The damage to the neck structures will be minimal as there is minimal force only used, most of the times it causes only the venous obstruction so there will be continuous flow of carotid artery. Due to venous occlusion alone there will be no return of blood to the right side of the heart resulting in congestion of brain. So if even the hand or any bodily parts touches the earth then it is partial hanging.

Hanging is always suicidal, in rare occasions accidental or homicidal, so the incomplete or partial type is the most common, axial traction will be minimal in case of partial hanging which results in only minimal injury to the cervical spine[23] unlike complete hanging.

Depending upon the position of the knot it is classified as

1. Typical hanging
2. Atypical hanging.

When the knot is placed on the back of nape of neck or behind the occiput. Then it is called **typical hanging** which is not common one. The pressure will be more exerted on the trachea than the carotid and jugular but there will be equal pressure on both the right and left side of the carotid. The congestion of the head and neck will be comparatively more on the typical hanging unlike atypical hanging where the obstruction will be on only one side most probably.

According to **Terazawa** in an article mentioned that the obstruction of the arteries and airway during hanging are mostly of typical type in nature[24]. Usually the ligature mark will be absent on the back of nape of neck due to the ligature materials pulled upwards and there will be no contact of ligature material with the skin on the back side but the mark will be present on the opposite side i.e., on the front of neck which is horizontal in nature.

When the knot is placed on any site other than the back of nape is called as **atypical hanging**, the area where the knot will be present are mastoid, mandible, even under the surface of chin, the mastoid is the most commonly involved area.

The pressure will not be equal on both the sides as the knot will pull towards suspension point, so the damage will be more on the side opposite to the knot placed. If the knot is on the right mastoid then the injury to the vascular structure will be more on the left side i.e. the obstruction of jugular vein or sometimes rupture of it, intimal tear on the carotid, subcutaneous soft tissue injuries, ligature mark are present, if the knot is present on the left mastoid vice versa is true. The knot on the chin is very rare, in this there will be minimal features of asphyxia as there is no strong compression of the airway structures, longer time is needed to compress the trachea. The asphyxia sign, other injuries to the neck structures like soft tissue injuries, muscle contusion, congestion of the laryngeal structures, will be very less in case of knot on the or below the chin and the ligature mark will be totally absent. The cause of death in case of knot on the front of neck or below the chin is due to partial occlusion of jugular system which results in decreased blood to the right atrium.

In a study conducted in Mymensingh medical college on 2005 among the 66 cases of hanging the results shows that knot position on the back of nape of neck 21.21 percentage, on the right side of the neck 25.75 percentage, on the left side of the neck 31.81%, in front of the neck 21.21%, thus the most common form is atypical hanging which constitutes nearly 80 **percentage** of the cases the remaining cases only goes for typical hanging.

TYPE OF MATERIAL USED:

The person who commit the suicide will be in impulse state so they can use materials whatever available at the time of the act, only few do after planning so they can buy or use the rope which is present in the home. The commonly used materials are rope, sari, curtains, bed sheet, blouse, and torn clothes, electric wire which is used for domestic supply, belt, shoe lace, Dupatta, and muffler. The broad surface material will produce minimal pattern of ligature mark on the neck, the injury will be very less on the underlying structures like soft tissue bruise. Thin rope like material will produce more congestion and soft tissue bruise due to that rope will penetrate the deeper layers of epidermis that will tight the neck structures and the structures beneath the ligature will be more congested, bruised, sometimes the jugular or carotid can be ruptured due to the pressure given by the weight of the body. If belt is used their pattern is clearly seen on the neck as two horizontal lines with intervening belt areas, if beaded chain is used then it produce the pressure

abrasion as beaded which is type of patterned abrasion. The furrow will be deeper in rough narrow material, in broader soft material the ligature furrow will be superficial and sometimes faint marks only visible.

In a study which was conducted by the GCS medical college, hospital and research center, Ahmedabad.Regarding the ligature material used, the Dupatta is most commonly used, 40 cases among the 74 hanging cases which constitutes the 54.05% of the total, next common is nylon rope in 18 cases which constitutes 24.32% of the total, the remaining are Electric wire 5 cases(6.75%), sari 3 cases (4.05%), cloth 3 cases (4.05%), bed sheet 2 cases (2.70%), muffler 1 case (0.74%), curtain 1 case (0.74%), belt 1 case (0.74%).

TYPE OF KNOT USED:

The knot produced by the persons are usually two types one is slip knot where there is a running noose and another one is fixed knot in which knot will not move, in the first the movement of the rope is due to the suspension act on it. The knot will be on any side depends upon the individual decision. The type of knot has not major role in determining the injuries, as both the types equally contributes for the occurrence of injuries. But in a study conducted in a Kurnool medical college, Andhra Pradesh in the year of 2011 given as most commonly used knot is slip knot

That is out of 200 cases 118 cases were slip knot, the remaining constitutes the fixed and loop type of knot[25]. At the scene of crime on removing the ligature the investigating officers should cut the material away from the knot to release the deceased from the ligature.

CAUSE OF DEATH:

There are lot of mechanism for the cause of the death in case of hanging. From the historical view the pathophysiology of the cause of death in hanging is poorly explained. According to **Clement et al 2010** they are asphyxia which is produced by mechanically, jugular vein and carotid artery occlusion, parasympathetic nerve activation[26].

To determine the mechanism of death in hanging a committee was formed on 2006 “The working group on human Asphyxiation (WGHA)” and conducted various experiments on animals. They used rat as a model due to the anatomical considerations. **Boghossian et al 2010** conducted study on rat by hanging and got the following features.

a. The muscular movements including the tonic clonic will stop within 1 – 3.5 minutes after hanging the rat.

b. The total blood flow will cease within 4 – 8.5 minutes of hanging.

c. In these studies the obstruction of carotid artery which leads to decreased blood flow to the brain forms the major cause of death rather than the obstruction of the tracheal lumen which produces asphyxia.

On review of filmed hanging done on animal models which is given by **Sauvageau et al 2010**, the WGHA released their findings as following,

a. The conscious will be lost within 8 to 18 seconds.
b. The tonic clonic movements will start within 10 to 19 seconds.
c. The body comes to a position of decerebrate and decorticate rigidity soon after convulsions.
d. The muscle will get relaxed within 1 min 38 seconds to 2 minutes 15 seconds after hanging.
e. There will be jerky movements of the body separately for variable time starting from 1 minute 2 seconds to 7 minutes 31 seconds.
f. Even respiratory movements on the abdomen start with a rhythmic fashion between 1 minute 2 seconds and 2 minutes 5 seconds.

The above give an idea of process of death during hanging, as from the above it is clear there will rapid unconscious after hanging, it might be the one of the reason why most of them choose it next to consumption of poisonous substance among worldwide.

Here we mentioned some of the causes which occur during the hanging, most of the time there will be mixture of these causes, the most common one being the combination of asphyxia and the venous occlusion. In rare occasions all the causes has been present in single individual itself.

The immediate causes are

1. Asphyxia.
2. Congestion due to occluding venous channels.
3. Combined asphyxia and venous congestion.
4. Cerebral hypoxia by carotid vessel block.
5. Reflex vagal inhibition due to stimulation of carotid bodies.
6. Fracture or dislocation of the cervical vertebrae.

The delayed cause of death is due to

1. Aspiration pneumonia.
2. Infections.
3. Edema of lungs, larynx, ARDS.
4. Hypoxic encephalopathy.
5. Infarction of brain, seizure.
6. Abscess of brain and cerebral softening.

Asphyxia in the Greek defined as (A = without, phyxia = heartbeat).Asphyxia literally means is a condition which produces ‘lack of

oxygen' or 'deficient of oxygen supply' to the blood so there is poor oxygenation to the tissues and various organs. According toAlaska Air Medical Escort Training Manual the hypoxia is defined as hypoxia is "insufficient supply of oxygen" to the demands of the body. In general asphyxia produces one of the types of hypoxia. Most of the times asphyxia leads to coma and death and many cases have been noted till now[27].

The hypoxia produce cerebral anoxia[28] and hypoxia is classified into four main categories they are

1. Hypoxic hypoxia – In which there is prevention of air entry into the lungs as in compression of neck or decreased partial pressure of oxygen as in high altitude. Divers, mountain climbers, aviators[29], are having high risk of developing this kind of hypoxia.
2. Anemic hypoxia – there is diminished level of hemoglobin so transfer of oxygen is affected as in carbon monoxide poisoning, methemoglobinemia, chronic anemia etc.,
3. Stagnant hypoxia – the blood flow is not sufficient as in decreased circulatory volume, pooling of blood in gravitational forces.
4. Histotoxic hypoxia – the body tissues cannot able to utilize the available oxygen as in cyanide poisoning, alcohol consumption etc.,

The deficient supply of oxygenis produced by various methods that can be classified under two broad categories a) Mechanical b) chemical.

Mechanical asphyxia produced by

1. Hanging- external compression to the neck which obstruct the trachea, a minimum of 15 kg is necessary to occlude the tracheal lumen, the compression of neck by the ligature causes the posterior part of the tongue to obstruct the pharynx, which makes the epiglottis to obstruct the larynx also.

2. Strangulation by ligature and manual strangulation- external compression of the neck both by ligature and by the hands(throttling), the most important differentiating features of these two from hanging is in the first there could be injuries to the laryngeal structures, bleeding into the surrounding soft tissues and muscles, possibilities of hyoid bone fractures in case of throttling. In case of strangulation death due to asphyxia is rare, the common cause of death is due to vessel occlusion so there would be more features of congestion on the head and neck.

3. Traumatic asphyxia- mechanical fixation of the chest or compression of the chest which results in respiratory arrest due to stampede effect which occurs mostly in accidents. Here there is no respiration or only

minimal respiration, so air entry prevented which results in asphyxia. In most of the cases there will be gross compression to the chest and abdomen which makes them unable to breath. The common cause are multiple deaths occur in case of fire accident in theatre or play ground where the crowd gathered in a closed place mostly it occurs in football ground. The another common cause is crushing of the person by falls of the earth which occurs in coal mining during tunneling, the recent coal mine disaster which took place on2014 in Turkey is one of worst disaster where more than 100 deaths occurred and in Tamilnadu building collapse on July 2014 where nearly 100 people have died are examples of traumatic asphyxia. Jack knife position where there is indirect compression of the chest and abdomen because of the position that his thighs and knee are forced against his chest. The important post mortem finding in case of traumatic asphyxia is intense congestion, petechial hemorrhage, cyanosis above the level of compression.

4. Postural or positional asphyxia which occurs mainly due to the position which prevents the person to breathe properly, most common examples are restraint asphyxia caused by the police officers during the arrest or suppression of riot in which there will be twisting of the neck or compression of trachea or elevation of the

tongue to the hypo pharynx. Postural asphyxia commonly occurs accidently among the intoxicated persons. We have to rule out other causes of respiratory arrest to say it as positional asphyxia, like food particles in the respiratory passage which was aspirated after intoxication, cardiac disease should be ruled out, and poisonous gas inhalation should be ruled out. But Byard 2008, says that the person with preexisting cardiovascular diseases or respiratory diseases are predisposed to postural asphyxia.

5. Sexual asphyxia – most common manner is accident, the compression of neck by ligature produces some kind of sexual pleasure in case of perverted man, the gap between to get sexual pleasure and to get unconscious is very narrow because of that most of them will die in hanging position. The scene of crime help to identify cause of death in these cases.**SHIELDS ET AL 2005** formed a criteria called **HAZELWOOD CRITERIA** which helps to arrive a manner of death in autoerotic deaths, the important things which included are

    a. Sexual activities associated with no one there is almost always individual play alone.
    b. Individual will be more on sexual fantasy aids.

c. There is history of dangerous sexually perverted practice previously, identified by visiting the scene of crime.
d. the other manner of death are excluded by visiting the scene of crime and post mortem examination of the individual which shows no apparent homicidal in nature, and there is no suicidal indication which was given by the relatives.

6. Drowning – entry of water into the larynx and lungs prevents the entry of air in to the lungs causing asphyxia. The water along with the mucous mixed with the violent respiratory efforts forms a froth which is fine and copious in nature which obstruct the airway and produce a condition called emphysema edematous lungs.

7. Smothering, gagging, bansdola, overlaying, plastic bag suffocation, choking prevents the entry of air to the lungs by various means.

8. Smothering and traumatic asphyxia combines to form burking.

9. Garroting is a type of ligature strangulation which is practiced as method of execution in Spain. So called the device Spanish windless.

Chemical asphyxia can be produced by

1. Poisonous gases as in case of burns which produce carbon monoxide (CO) and carbon dioxide, cyanide gas(HCN), hydrogen

sulphide(H2S). HCN and H2S combined with other enzymes to interrupt the cellular respiration, while CO has 230 times more affinity towards hemoglobin when compared to the oxygen, it can easily bind with the hemoglobin to decrease the delivery of oxygen to the cells.

2. Certain drugs and anesthetic agents – they produce the asphyxia by two means firstly when the drug paralysis the muscle again by mechanically it can produce asphyxia by reducing oxygen to the lungs or secondly when certain drugs interfere with the aerobic metabolism that produces ATP which is needed for our body for all kind of metabolism, so in the second the oxygen usually reaches the tissues unlike the first but the toxin will interfere in the chemical reactions which is necessary to produce ATP.

The important asphyxia sign are Tardieu spot or petechial hemorrhage on the conjunctivae, mucous membranes, surfaces of heart, lungs, kidney and many other internal organs, facial skin and in eyelids due to the capillary rupture, the red blood cells comes out of the vessel and forms a pin point bleeding site, congestion due to the decreased venous return to the heart, cyanosis which is seen as bluish discoloration of the conjunctivae, lips, bed of the finger nails. These three sign forms the stigmata of the asphyxia deaths. According to **Ely and Hirsch** 2000, and **Lasczkowski** 2005 the petechial

hemorrhages are due to that there is a mechanical disruption of the vessel walls.

But according to the **Bernard Knight** the petechial hemorrhages are not due to capillary dilatation and its rupture, it is due to its distension and the rupture of venules which is caused by the block of jugular venous system. The decreased venous return also due to obstruction of the jugular veins not due to results of asphyxia as in asphyxia most of the authors says there will be capillary dilation with engorgement which leads to decreased blood flow to the right side of the heart.

VENOUS OBSTRUCTION:

The jugular vein is present superficially so the force needed to obstruct the vessel is very minimal. Most of them says that 2 kg of weight is enough to occlude the venous system which is present more superficial compare to the carotid artery. The venous system get occluded even just by turning the face to one side so the brain will be congested, or even 1.3 kg of weight is enough to impair the venous drainage from the head.

In complete hanging due to the increased weight of the body there will be obstruction of both the blood flow to the brain and the drainage of the brain because of cutting of the blood flow towards head the face will appear pale instead of congested. But in case of incomplete or partial hanging most of the

time only drainage is affected so there is flow of circulation to the head but the outflow is obstructed because of that the brain circulation will be increased and the brain look more congested.

In typical hanging the knot is on the back so the ligature around the neck compress the neck structures symmetrically i.e., both the jugular venous system get compressed equally, here the same process, only the inflow of blood, no drainage so the head will show increased congestion and increased intra ventricular pressure.

In atypical hanging the area of the neck on the side of knot will not get compressed due to pulling of ligature material towards the suspension point by weight of the body. In these cases only one side of the jugular venous system are constricted the other side will be free in most of the cases, soblood in the brain get drained through the other free side of the venous channel, still there will be congestion because before they could drain it completely the person would have died at the time, but the congestion will be minimal unlike typical hanging.

Venous occlusion along with the other structure involvement are depends upon the type of material used for constricting the neck. The broad soft material like duppatta in complete hanging will occlude venous system and take more time to constrict the carotid and much more time to occlude the

tracheal lumen when compared to the thin rope like material which is used for hanging where in the last, the thin rough material will penetrate the epidermal layer quickly to occlude the structures beyond the jugular vein. The value of the ligature material used is ascertained from the above said examples.

PATHOPHYSIOLOGY OF VENOUS OBSTRUCTION:

Due to the occlusion of jugular system, not only the head is congested all the internal organs are congested because of decreased drainage to the right atrium through the vena cava. Due to the increased flow there will be distension of the venules and after a period of certain pressure it's give a way to get ruptured and forms pin point petechial hemorrhages[30]. This mechanism is on debate as some of the authors are of the opinion that the petechial hemorrhages are due to the pre – capillary dilatation with engorgement which get ruptured and some of the authors strongly says that the hemorrhages on the mucous membrane of different organs, conjunctivae are due to the venules disruption. When the jugular system obstructed and the common carotid artery not obstructed means there will be flow of blood to all parts of the body which causes local hypertensionwhich leads to the rupture of the capillaries which forms petechial hemorrhage named as Tardieu spot[31].

Combined asphyxia and venous block are the major cause of death due to hanging, here the asphyxia may not be due to the obstruction of the respiratory lumen, if it so then the other carotid arterial occlusion also involved

with this because to occlude the trachea 10 to 15 kg is needed but to block the carotid vessel only 4 to 5 kg is enough. So if the force is around 10 to 15 kg definitely it would block carotid also. The possible mechanism to explain is that raised intracranial pressure because of venous blockade of drainage of cerebral circulation to the heart, will compress over the respiratory centers which are present on the medulla oblongata, inferior part of the brainstem areas which produces asphyxia. But according to **Krishnan Vij** the combined effect of asphyxia and insufficient cerebral flow is the most common cause of death in hanging.

CEREBRAL HYPOXIA:

A quote is there that for a successful suicide there should be cerebral hypoxia. This is secondary to the external compression of the neck which obstruct the common carotid artery, because even tracheostomy patient died by hanging themselves using the ligature material which constrict above the tracheostomy wound. It is produced by the occlusion of the carotid vessel which is present within the carotid sheath and to a lesser extent which involves the mechanical obstruction of the airway reduces the oxygen to the brain. The force necessary to occlude the artery is around 4 to 5 kg which is little higher compared to the jugular vein obstruction, as the first one is present beneath the jugular vein. The obstruction of the carotid produces immediate loss of consciousness within few seconds so the person will go for a painless death

because of this mechanism most of them chooses hanging as a common method of suicide. Initially within second or two there will be tingling sensation which is followed by the rapid unconsciousness.

To cause the cerebral hypoxia all the four vessel should get occluded, namely two carotid and two vertebral arteries. If, even any one of the artery is not occluded means there will be a flow of blood to the brain which supplies needed oxygen to the tissues. When all the four vessels occluded means the force applied is nearly 15 to 20 kg as vertebral artery only blocked at this amount of force, meanwhile there is definite obstruction of trachea to produce asphyxia, as the force needed to occlude the trachea is only 10 to 15 kg. Some of them are of opinion that the force required to occlude vertebral artery is around 30 kg[32].

Death will be rapid if all the four vessel get occluded. If the perfusion continues through the other side of the vessel death will be delayed or the death can occur due to other means of mechanism like jugular vein obstruction or asphyxia. But even when the vertebral artery perfusion is continue, death can occur laterbecause of not able to compensate for the loss of oxygen to the brain tissues which was stopped by the carotid occlusion.

One more issue is if even bilateral carotid artery and jugular venous channel obstructed and flow through the vertebral artery continues then there

will be problem in the draining of the blood which was supplied, here the cause of death might be due to the congestion of brain and if the person survived they are affected in the multiple areas of brain due to poor oxygenation at the different areas. Cerebral anemia or hypoxia is produced mainly in complete hanging as the body suspended fully there will be necessary amount of force which will act on the carotid vessel.

In partial hanging depending upon the position there will be minimal obstruction of carotid artery because when a person sliding down from the wall by putting the suspension point on the wall there will be sufficient force which is produced by the weight of the body to cause obstruction of artery, but if the position is just sitting or lying down only jugular system get blocked due to minimal force acting on the neck.

In case of typical hanging the ligature passes through the neck on both the sides equally, obstruction of the common carotid vessel also equal on both the sides which produces cerebral hypoxia. The chance for cerebral hypoxia is maximum when in complete hanging the knot is on the back of nape of neck because of the above explained mechanism. In atypical only one side obstruction is present and on the other side there will be a gap between the neck and the knot due to the pulling of the ligature towards the suspension point. Mostly the obstruction will be at the level of common carotid artery, in

rare occasion it may be on the external or internal carotid artery or both due to movement of the ligature due to the weight of the body.

The person who hang not always die at the place of hanging itself sometimes if they survive, the loss of oxygen to the tissues for certain period of time will produce a condition called hypoxic ischemic encephalopathy(HIE). There are lot of cases noted that death occurred after hospital admission due to hypoxic ischemic encephalopathy. A women aged 43 years survived for a period of 9 months with the help of mechanical ventilator support was suffered from hypoxic ischemic encephalopathy due to hanging, so delayed death can also occur afterinitial survived period due to HIE. It is very difficult to diagnose the HIE by any of the investigations available, mostly clinical diagnosis only available. To prove the Hypoxic ischemic encephalopathy we have to take tissue bit from the Sommers area which is present in the hypo thalamus.

Cerebral hypoxia or anemia can be classified into four different categories depending upon the location and severity of lack of oxygenation in the brain tissues[33].

1. **Diffuse cerebral hypoxia** – due to the decreased oxygenation in the blood level, there will be mild to moderate impairment of the brain normal functions.

2. **Focal cerebral ischemia** – A stroke which occurs in a particular region of the brain that can be either transient which lasts for 24 hours or acute. There are lot of conditions which produce stroke for example an aneurysm which present already in the brain get ruptured to produce hemorrhagic stroke, thrombus mainly due to the atherosclerosis block the lumen of the vessel to produce thrombotic stroke, sometimes embolus from the different parts of our body travelled to reach the brain to produce embolic stroke[34]. In stroke pathology the maximum cases are focal cerebral ischemia which was caused by the blockage of middle cerebral artery a branch of internal carotid artery[35].

3. **Global cerebral ischemia** – total blood flow to the brain stopped by complete obstruction of the vessels supplying the brain.

4. **Massive Cerebral infarction** – A "stroke", caused by total stoppage of the oxygen due to the disruption in the flow of blood to the brain which produces multiple massive infarcts over the brain.

Thus there is rapid death in cases of cerebral hypoxia when there is complete occlusion of the common carotid artery, if minimal amount of blood allowed to enter the area of brain then there will be delayed death due to hypoxic ischemic encephalopathy.

VASOVAGAL INHIBITION:

Difficulty arises in cases of hanging when there is no positive post mortem findings other than the inquest report. So this could happen in certain cases when there is stimulation of the carotid body by the ligature material which leads to sudden death. Death is so rapid even not giving enough time to produce other features like congestion, petechial hemorrhage, cyanosis, etc., which are seen in other cases due to hanging. For congestion or petechial hemorrhage to occur in cases of hanging there should be at least 15 to 30 seconds needed, but in cardiac arrest due to vasovagal inhibition it is immediate within few seconds not giving that enough time to produce the signs of asphyxia.

When pressure given to the carotid sinus baroreceptor which is present over the bifurcation of the common carotid artery, the receptors get activated and through the sinus nerve, a branch of glossopharyngeal nerve it reaches the nucleus tractus salitorius present on the medulla. From the medulla signal is transmitted to the heart through the vagus nerve it produces sudden death.

Sudden fall in cold water stimulate the parasympathetic system which never delays death, as in cold water drowning, there is no post mortem findings suggestive of drowning like emphysema edematous, and water in middle ear, water in intestines because of the death is sudden within few seconds without giving enough time for entry of water in to the lungs.

Activation of parasympathetic nerve in cold water is not for everyone that is depend on the individuality.

Cases have been noted during laryngoscope procedure due to the stimulation of the nerve plexus which are present over the larynx and pharynx which produce sudden death. When someone is in emotional stress or fear then there will be increased adrenal response which sensitize the myocardium and stimulation of parasympathetic nerve will produce sudden death. Records are there of cases of vasovagal cardiac arrest due to squeezing of the testicles. Stretch receptors are present on the cervix, so during dilatation and curettage without anesthesia, dilatation of the cervix will produce bradycardia and arrest.

There is a debate regarding the time of survival after the stimulation of parasympathetic system, some say it will produce arrhythmia for sometimes whether bradycardia or ventricular fibrillation then it causes death and others are of the opinion it will produce sudden death without any arrhythmias. The second opinion matches with the mechanism of death in hanging, because even 8 to 10 seconds are more than enough to produce the signs of compression of neck vasculature, if there is no sudden death in vasovagal inhibition of heart means then definitely there will be other signs which are explained in vasculature obstruction. The death is sudden that is why there is no time to produce other features of hanging. Sometimes initially the person is suffering from the obstruction of neck vessels by the compression of the ligature over

the neck, after sometime due to the movement of the rope, it may stimulate the carotid receptors resulting in sudden death later, here the other features of hanging will be present.

The manual strangulation are having more chance to produce the reflex vagal arrest than the ligature strangulation because in the first there will be movement of the fingers which stimulate and the force given also higher in case of throttling. Blow to the neck also produce sudden death due to the same mechanism. But a death due to a simple blow is considered as less culpable when compared to the more grip given by the person during throttling.

In case of hanging, the cause of death as reflex cardiac inhibition obtained only after there is no findings related to other causes of hanging and there is nofindings of other cause of death in general, along with the strong history suggestive of hanging. Otherwise the opinion could not be arrived as cardiac inhibition. Mostly there will be no specific features of hanging in reflex cardiac arrest.

Standring 2005 described carotid body is present as a swelling on the lower part of the internal carotid artery which function as a stretch or baroreceptor, which responds to the changes in the vessels which is induced by the arterial blood pressure. These receptors play important role in regulating the short term BP control. When the impulse received by the carotid body they

transmit the signal to the brain through the afferent fibers in the sinus nerve, which is a branch of glossopharyngeal nerve, in the brain the impulses are received by the nucleus tractus salitorius (NTS) which is present on the medulla, finally from that signal send to the heart through the vagus to cause reflex arrest.

In **1996 Berne and Levy** said that the stimulation of the parasympathetic nuclei or vagal nuclei, which is present in the medulla produces bradycardia, sympathetic nerve impulses to the peripheral blood circulation is inhibited by the stimulation of the nucleus tractus salitorius which produces peripheral vasodilatation, both of the effects combined together to produce hypotension and bradycardia.

The baroreceptor reflex mechanism is very instantaneous which is less than one second but the hypothalamic defense area in fight or flight situation get stimulated and inhibit the reflex. The central pathways which control the cardiovascular system include hypothalamus, cerebral cortex, cerebellum and medulla oblongata **(Sunthareswaran 1998).** When experiments done on the dogs with old myocardial lesions by **Schawartz et al 1988**, chances of ventricular fibrillation increased in cases of alteration in the sensitivity of baroreflex.

Death due to the activation of parasympathetic nervous system have been reported, for many years by **Simpson 1949, Hirsch and Adams 1998**, when there is pressure given by blow or ligature to the neck or during the medical procedures or blow to the groins result in the rapid death of the individual. When the sensory nerves presented on the surface of the skin, pharyngeal mucosa, glottis, peritoneal layer which covers the viscera, pleura etc. get stimulated, the parasympathetic nervous system get stimulated, the afferent nerve sent the signal to the brain which gives efferent through the Vagus to the heart resulting in bradycardia and cardiac arrest. According to **Willich** 1993 Stimulation of the vagus result in profibrillatory reaction to the atria but it paradoxically reduce the ventricular arrhythmias.

The critical region of the vasomotor centers are located on the 3rd ventricles, mid brain, medulla oblongata. When there is interruption in the autonomic nervous system between the heart and the brain in case of trauma this will result in the immediate death without much delay **(Hirsch and Adams 1998)**. The mechanism of cause of death for the asphyxia deaths has been explained by **Purdue 2000** recently in that he has explained in detail regarding the mechanism of sudden death due to the compression of the neck structures.

If there is prolonged pressure to the carotid artery below the level of the bifurcation of artery where the carotid body present there will be activation of

the sympathetic nervous system which result in increased chances of ventricular fibrillation and ectopic beats particularly in emotional stress or fear. When there is pressure on the carotid body or above the level of it, the parasympathetic nervous system get activated which produces asystole commonly among those who is having sensitive baroreceptors. The parasympathetic nerves also activated by applying strong force to the solar plexus (pit of the stomach), inner aspects of knees, philtrum of the upper lip, cervix, external genitalia as mentioned earlier.

FRACTURE DISLOCATION OF THE CERVICAL VERTEBRAE:

HANGMAN'S FRACTURE:

The most important but one of the rare cause of death is fracture of second cervical vertebrae axis. This is a controversial as the cause of death is still found to be injuries to the neck structures not the fracture of axis vertebrae. The cervical vertebrae fracture can also occur in motor car accident, fall injury, blow to the head. The name hangman fracture was designed by Schneiderin 1965[36]. The hangman fracture are common among the judicial hanging. The name is a misnomer as the fracture denotes the persons who hanged the accused, but originally the fracture is to the persons hanged on judicial hanging. The hangman is the person who used to hang the prisoners. The correct word to denote the fracture is Hangee fracture.

The fracture mainly occurs due to the maximum force acting on the craniocervical junction. There are two mechanism involved in the fracture one is hyperextension and distraction which occurs in hanging which causes the transection of the spinal cord and immediate death, the second one is hyperextension and compression which occurs in car accident where there is minimal or injury to the spinal cord so the person may survive after the accident. The fracture in cervical vertebrae usually involves the pedicles and the dens will be intact.

There are many factors which play a role in the fracture of axis vertebrae and leads to sudden death. The type of hanging itself play a key role, in partial hanging the part of body weight will be on the ground so there will be no force acting on the craniospinal region to produce fracture. But sometime the person fall from a height from the chair who tie the ligature at a highest suspension point will sustain injury to the cervical vertebrae initially and he may be in the position of partial hanging later.

In complete hanging, the total body weight suspended on the air without touching the ground, so there is a possibilities of force acting on the cervical vertebrae which leads to fracture of C2 vertebrae. The fall of height from the hanging position is important as too long rope will cause decapitation and too short rope will produce no injury to the vertebrae, thus the fall of height should be of medium height to produce the fracture. The position of knot place a

major role in producing the hangman fracture. In typical hanging the knot on the back side will cause a hyper flexion so fracture is at the odontoid level not at the pedicle, so it will not cause sudden death. The atypical hanging are of more favor for the production of Hangee fracture but in that whether it is sub mental or sub aural will always raise a question or the answer for this always controversial.

The history of hangman fracture is, the name came from the **Judicial Hanging**, which was done by a particular person who was in charge for executing the prisoners on the allotted date at particular time. The cause of death in judicial hanging was attributed to asphyxia and obstruction of the blood supply to the brain which produces unconsciousness within few seconds and painless death to the persons until late 18th century. That is why in the olden days when a person executed by hanging they allowed more period of time in the hanging position itself to cause the death[37]. Added to this the convulsive and jerky movements further explain the most probable cause of death in hanging is asphyxia[37]. But after certain studies conducted by various authors revealed that the cause of death in judicial hanging is related to the fracture of cervical vertebrae.

In 1908, **Dr Woodjones** conducted a study on 100 people who were executed by hanging in the period of Roman Empire, concluded with the skull fractures are present in most of the deaths. Jones in his study on 1913

conducted on executed deaths revealed that the cervical vertebrae is the reason for the immediate death in hanging until before his work the cause of death as cervical vertebrae is not established[38]. But the previous studies conducted by various authors given the fracture of cervical vertebrae even including the odontoid process were included the cause for immediate death before Jones literature[39, 40]. But Jones in his studies says that the odontoid process not at all involved in the fracture. Jones concluded with that the common feature noted in the cases were fracture of posterior arch of second cervical vertebrae which still attached to the 3rd cervical spine and the anterior axis of 2nd cervical vertebrae along with the atlas remain connected with the base of the skull. The reason for the rapid death in the cervical vertebrae fracture are violent jerk caused by sudden drop of the person who was standing in the trap door which was made according to the persons weight and height, which cause backward movement of the head resulting in the fracture of the vertebrae along with the injury to the spinal cord. The length of the drop will be usually greater than the height of the victim.

The study was conducted among the 5 people in all sub mental knot was used, an unyielding object in the front of neck that is sub mental knot will push the head backwards resulting in hyper extension at the cervical vertebrae. This explains that the sub mental knot will cause cervical fracture which is also accepted by the **Vermoontan,** he also mentioned in his studies that the

ligamentum apices dentis and the ligamentum transversum Atlantis are not involved in the fracture[41]. He given a special note on the position of theknot was not on the subaural side if the vertebrae fracture occurred. In 1928 **Wolff** described among the 5 cases of hanging cervical fracture present when the knot is behind the ear[42].**Schneider** said that initially the knot may be in the sub aural position but during the time of drop it may change to sub mental that may cause the cervical vertebrae fracture but not the sub aural knot.

The instantaneous death in case of judicial hanging depends upon the position of the knot and the long drop. In the early period of 19th century the death of the executed person attributed to asphyxiation during that period mostly sub mental knot was used. After the introduction of long drop the sub mental knot was not suited, as the hangman afraid of there may be slippage of the knot, so they substituted it with sub aural knot but still the cause of death on postmortem examination found to be asphyxiation. There will be fracture of skull base when we used sub aural knot but no cervical fracture. Wood jones in his studies published, depending upon the skull base fracture we can identify the position of the knot. He reported only one case with cervical fracture where the knot is on the sub aural side. Before his result itself there are lot of mention regarding the sub mental knot which causes the cervical fracture.

The long drop was first introduced in the year 1818, initially they have used a drop length of 12 – 18 inch. In this the death was not instantaneous,

again caused by the asphyxia alone. Sir **Bernard Spilsbury** a Pathologist during the period of 1877 – 1947 given information of addition of 3 inches to the previous one will cause sudden death. This he enclosed based on his knowledge obtained by the post mortem examination of the convicts who were executed during his period. **William Mar Wood** in 1872 introduced the long drop to the hanging for the purpose of execution in England. He given his recommendation as drop of 7 to 10 feet will cause sudden death. Before introduced in England the concept of long drop has been practiced in Ireland. The only dangerous thing to view in long drop is fear of slippage of the sub mental knot. So most of the hangmen preferred sub aural knot when long drop is used. Sometimes the using of long drop will produce decapitation because of significant variability which was left to the hangman discretion[43]. In Ireland among the first two cases where long drop was used, first there was near complete decapitation and in the second there was a complete decapitation. Marshall found that the sub mental knot were more effective than the sub aural knot during his work in 1866[44]. He also developed lather chin pad to avoid the slippage of the knot from the position.

Schneider and his colleagues extensively studied regarding the biomechanics behind the cervical fracture dislocation of cervical vertebrae in case of execution by hanging. They noted that the 3rd cervical spine forms a fixed position in between the lower cervical vertebrae and the craniocervical

junction. All the forces acting downward from the skull through the atlantooccipital and the atlantoaxial joints which divided in the frontal plane and are united in the body of the axis. The force continue downward, turning ninety degree and are distributed in three distinct lines, along the lines of vertebral bodies and the disc medially and along the line of pre and post zygapophyses bilaterally. All these three lines passes through the weakest part of the arch of the second vertebra which is more prone to get fracture causing an avulsion fracture of the second vertebrae.

During judicial hanging the sub mental knot and the long drop produces hyperextension and distraction which produces the rupture of the ligament system, fixing the cervical spine anteriorly and leaning of the arch of the second cervical vertebra on the 3rd cervical vertebrae results in fracture of the vertebrae. Cervical vertebrae is completely detached from the cervicocranial junction by continuous longitudinal traction which results in extremely serious neurological features that are usually fatal in nature.

Even cases of cervical vertebra fracture can occur in car accidents also, Schneider and his colleagues presented lot of cases of cervical fracture following car accidents in 1965. Several authors reported cases of cervical fractures following car accidents during the period of 1950 and 1960. **Gilbert Hamilton** said that there is similarity between the fracture of cervical vertebrae following the car accidents and the fracture caused by the judicial

hanging. The cervical vertebral fractures following car accidents are produced by the hyperextension and compression which are less dangerous when compared to the fractures produced during judicial hanging.

In judicial hanging the cause of death is a controversial, most of the time it is attributed to the hangman fracture of axis vertebrae. Many researchers found that in judicial hanging the fracture of cervical vertebrae is an exception, the cause of death found to be the range of head and neck injuries, more specifically it attributes to the obstruction or tearing of the carotid and vertebral arteries which leads to formation of thrombosis resulting in cerebral ischemia. The immediate loss of consciousness and the instantaneous death is depend upon the position of the knot and the length of the drop. **Mr. George Kelly** who was wrongfully executed for murder at Walton prison, the skeletal remains of him exhumed and examined in the year 1950. Only the first cervical vertebrae was found as fractured and there is no fracture of second cervical vertebrae called as hangman's fracture. **Albert Pierrepoint** he was the hangman of this case, said that there is delay in the death of Kelly when compared to the usual time, but there is a sudden unconsciousness which was attributed to the vertebral artery rupture or obstruction as a result of the above mentioned fracture of first cervical vertebrae.

Skeletons of six felons executed by judicial hanging was recovered from the two Canadian prisons during the archaeological excavations. They

observed injury to the various skeletal elements which was induced by the judicial hanging. The injuries seen were fractures of occipital bones, body of 2nd cervical vertebrae, transverse process of C1, C2, C3, and C5 vertebrae, hyoid cornua, styloid processes. Though the hanging technique is uniform for all the cases using sub aural knot, the injury to the neck structures and the cause of death was different for different individuals. The reason for this may be the difference in hanging practices, but the anatomical variation in individual also contributed to this variation in injuries to the structures and the cause of death.

DELAYED CAUSE OF DEATH IN HANGING:

Most of the time the death will be immediateor rapid in cases of suicidal hanging[45]. But it will not always produce instantaneous death, in some cases the death will be delayed due to various reasons. Death can be delayed, that is the victim can be survived after a period of prolonged unconsciousnessbut this is rare one[46]. Even in olden days records are there the person executed by judicial hanging was wake up during or at the time of burial. As most of the deceased decided to suicide by hanging within a few minutes of impact on them, only few doing it by planning, so as soon as they attempted most of them are rescued by their relatives and they will admit in hospital and after many days they are dying due to various reasons. Even though they rescue as soon as possible, the blood supply to the brain if cut off for few seconds will

cause danger to them in the later period. Some of the individual may be conscious initially and some of them may be unconscious from the starting period of admission itself. Few cases have been noted where the death is delayed for a period of average of 18 hours to 4 days[47]. The common cause which leads to death after a period of survival are

a. Pulmonary edema.
b. Hypoxic ischemic encephalopathy.
c. Infarction of the brain due to thrombus formation.
d. Aspiration pneumonitis.
e. Adult respiratory distress syndrome.
f. Infections.
g. Brain abscess.
h. Convulsions.
i. Raised intracranial pressure.
j. Multi organ failure[48.]

PULMONARY EDEMA:

As soon as the persons rescued they develop mostly respiratory distress and neurological problem. Among these pulmonary edema is the one of the important complication which developed, soon after rescued from the airway obstruction or suicidal hanging. Occurrence of pulmonary edema are noted among the cases where there will be sudden release of pressure from the upper

airway compression[49]. There is no definite time period for the occurrence of pulmonary edema, mostly within few minutes it develops, in some the development of pulmonary edema will be delayed. The cause of delay for its development is not understood but it may be related to the severity of the compression to the airway structures and to the rate of onset of pulmonary edema[50].

Pathophysiology of pulmonary edema:

The definite mechanism for the development of pulmonary edema after the rescue efforts from the hanging is not clearly understood. Some of the authors described the cerebral ischemia during hanging leads to the release of vasoactive substances like serotonin, kinins and histamine. All these substances together with the hypoxia leads to pulmonary vasoconstriction, pulmonary hypertension and pulmonary congestion[51]. Some of them support the theory of increased capillary permeability due to the damage of the pulmonary capillary membrane which results in the formation of pulmonary edema. Another theory suggests that the hyperemia in the lungs is the cause of pulmonary edema. If the tracheal obstruction is rapidly removed, there is sudden fall in the intrapulmonary pressure which results in increased blood flow to the heart and also increased flow to pulmonary vasculature results in hyperemia[52].

Any patient who is having hypoxia from hanging or relief from the obstruction of the airway should consider as a case of pulmonary hyperemia even though the chest is clear, because he may develop the pulmonary edema at any time after the admission. The development of pulmonary edema is usually rapid, still the time of onset and rate of development of pulmonary edema depends upon certain factors such as duration and severity of the airway obstruction, degree of neurological complication. In hanging the persons survived after a period of time usually will not or develop minimal functional disability, the cerebral and thoracic injuries are responsible for the development of the functional disability[53].

CEREBRAL INFARCTION:

Harish D. et al (1992) has reported cases of delayed death after attempted hanging. The reported cases are, cerebral brain damage due to cerebral hypoxia delay the death for a period of 7 days, the case where the lungs are consolidated bilaterally in which there is delay in the death for a period of 14 days. The other important cause for the delayed death in hanging is cerebral infarction. The mechanism, for which the cerebral infarction occurs is in hanging there will be intimal tear on the carotid or cerebral arteries. This will produce ulceration over the intimal tear, which slows the circulation to the distal branches. This tear act as a nidus for the formation of thrombus,which obstruct the blood vessels which supply the blood to the cerebrum, resulting in

the formation of cerebral infarction. The presence of atherosclerotic lesions will predispose to the formation of intimal damage and simultaneous thrombus formation. This leads to the complete occlusion of the cerebral arteries especially the middle cerebral artery a branch of internal carotid artery.

The localized infarct in the particular area is due to occlusion of blood supplyto that part resulting in the hypoxic brain damage to that particular part alone, and the death can be delayed because of that vital centers are not involved. After the involvement of vital centers the death can be quick. When the person is released from the suspension, there is certain degree of apoplexy and the death may be delayed for period of few days. Depending upon the site of damage in the brain the symptoms vary which includes amnesia, neurogenic disturbances[54], and amnesia.

Agarwal et al described about a case, where she was survived for period of nine days after a hanging attempt, she was in unconscious throughout the period of admission and unfortunately died due to the damage of the cerebrum which is caused by the brain hypoxia or anoxia[55].**Verma Sk and Agarwal Bbl** reported a case of an accidental hanging who was trapped in the buildings lift and was hanged accidentally. This victim also survived for a period of 39 days and died later[56]. **Maxeiner** described about the cases of delayed death among the six cases of suicide in the early period[57]. All of them were unconscious during the period of admission and till the end of their lives.

Vaghela Dr and Patel PR reported a case of hanging where the person committed suicide by using hanging by himself at his home, initially he survived and he was treated, but after a period of 36 days because of irreversible brain damage and respiratory arrest the person died[58]. A case was reported by **Fremingston K. Marak and R Balaraman** in which the girl was released from the obstruction immediately in spite of that she died at the hospital after 28 days in the unconscious state, she never regain the conscious state during the period of hospitalization[59].

In the above stated cases all the victim are in unconscious state or developed neurological problems, **Haussmann and Betz** reported a case which was totally opposite to the above mentioned cases, here the victim was released from the obstruction and the victim never developed any neurological problem and was in the conscious state till the death, that is died after 4 days of attempted hanging. In this case the cause of death found to be the infarction of the cerebrum by the thrombus formation which is due to the partial rupture of the carotid arteries which later on produces the death.

In hanging due to the decreased blood flow to the brain, due to the pressure on the carotid vessels there will be definite injury to the brain cells. Encephalopathy can be developed due to the severe hypoxia, necrosis of the individual cells leads to inflammatory reactions ultimately results in the swelling and edema of the brain. From the above mentioned cases we can have

an idea that the dangerous period in attempted hanging is not only due to the force which obstruct the neck structures but also because of how soon the ligature applied around the neck get released. The period of time after which death occur in case of hanging is not the exact when the persons survived initially. In every case of attempted hanging the delayed death should be in mind even though there is no symptoms in the early period.

ADULT RESPIRATORY DISTRESS SYNDROME:

Its occurrence in cases of suicidal hanging is rare one. But in hanging hypoxia can occur which produces pulmonary complications from the centri neurogenic ARDS. This syndrome is one of the poor prognosis for the victims. Mostly the persons who survived from the hanging initially would die of ‘bronchopneumonia’ or ‘pulmonary edema’. Aspiration is the main reason for the bronchopneumonia still the centri neurogenic cause also develops to pulmonary edema. The survivors would develop marked respiratory distress along with severe hypoxemia and right to left shunting in the presence of normal cardiac contour. Due to the increased amount of fluid in the alveolar space, high inflating pressure and positive end expiratory pressure were needed for the normal ventilation to occur.

In this syndrome there is rupture of alveolar capillary membrane, due to which there is exudation of the fluid into alveolar spaces because of this, there will be decrease in the function of the surfactant activity. In adult respiratory

distress syndrome, hemorrhages, atelectasis, vascular congestion and edema were present in the lungs as a post mortem findings. An experiment conducted on animals regarding this syndrome, injection of hypoxic blood alone to the brain produces adult respiratory distress syndrome. They considered that the possible mechanism for the occurrence of this syndrome is, disruption of cerebral autonomic function, in the presence of intact nervous communication leads to increase in the muscle tone of pulmonary vasculature. Due to hypoxia there will be increased secretion of the adrenaline which leads to transfer of fluid from the systemic circulation to the pulmonary circulation and there is increase in the pulmonary vascular resistance and the capillary permeability[60]. Due to the tourniquet like effect on the vasculature there will be vascular congestion along with pulmonary complications associated to the adult respiratory distress syndrome.

When compared to the negative pressure pulmonary edema after hanging the prognosis for the hypoxic induced pulmonary edema is very bad. One of the important measure to increase the survival period is providing adequate ventilation and oxygen. Treatment includes supportive measures and oxygen supplementation but mechanical ventilation and the PEEP may be required for long period of time[61].

HYPOXIC ISCHEMIC ENCEPHALOPATHY:

Not all the cases of hanging produces hypoxic ischemic encephalopathy, when the person survived but was in the hanging position for a sufficient period of time which decreases the oxygen supply to the brain in any means then it produce HIE. Reduction of blood supply to the brain by obstruction of the vessel or lack of oxygen supply to the brain leads to the HIE which is acute diffuse brain injury. The other name for the hypoxic ischemic encephalopathy is

a. Anoxic brain injury.
b. Anoxic encephalopathy.
c. Post cardiac arrest brain injury.
d. Anoxic brain damage.

Hypoxic ischemic encephalopathy is a complex diagnostic term which comprises a complex constellation of molecular and physiological injuries to the cerebrum induced by the lack of oxygen, cell injury or decreased flow of blood to the brain or combination of all these conditions **(Busl and Greer 2010).**

The concept of hypoxic ischemic encephalopathy is well known, but there is a lack regarding the other terms used to denote this type of injury **(ARCINIEGAS 2010).** The other names which denote the hypoxic ischemic encephalopathy like ‘anoxic encephalopathy’, ‘anoxic brain injury’, and

‘anoxic brain damage’ are in controversy, as the word anoxia means complete absence of oxygen in which the probability of survival is less. In near hanging, near drowning, drug intoxication there is cessation of respiration but circulation maintained for few minutes which leads to hypoxia alone not the anoxia, which produces dysfunction of the brain that will be transient in nature and result in less severe and permanent cerebral damage than those produced by the combined hypoxia and ischemia (cessation of both the respiration as well as circulation, example cardiac arrest) **(Greer 2006, Busl and Greer 2010).**

Hypoxic brain injury occur because of decreased oxygen level in the blood which could be due to failure of gaseous exchange which occur in the alveoli, decrease oxygen saturation level in the blood due to pulmonary dysfunction or interferences by other poisonous gases like carbon monoxide, or decreased hemoglobin level as in marked anemia. Perfusion of the cerebrum decreased, when the flow of blood to it is partially or completely obstructed as in obstruction of arterial flow in near hanging or near strangulation, in hypotensive or hemorrhagic shock where the blood pressure is very low, when the circulation stops completely as in cardiac arrest. In hanging there will be combination of the above mentioned mechanism to produce hypoxia ischemic encephalopathy.

INFECTIONS:

The most common infection to occur in case of hanging is bronchopneumonia. The patient on mechanical ventilator for more than 2 weeks are more prone to die of infections. Sometimes it can form brain abscess as the individual in the mechanical ventilation are having decreased immunity they are more prone to develop any kind of infection. After a certain period of time individual organ goes for failure resulting in multi organ failure and death.

Hypoxia leads to multi organ dysfunction which is caused by the balance between the pro inflammatory cytokines and counter inflammatory cytokines. If the ischemia leads to hyper inflammatory response then it causes the multi organ failure, on the other hand the counter inflammatory cytokines result from the ischemia also produce the same. In certain situations the counter inflammatory cytokines protect the tissues from the hypoxia if the organ escaped from the initial episodes. But in certain situations the counter inflammatory cytokines further aggravate the multi organ failure. If the ischemia occurs in the presence of primed poly morph neutrophil (PMN) the result will be bad. Similarly if the ischemia is associated with multiple hyper inflammatory cytokines released from multiple causes like tissue injury, blood transfusion then there will be bad outcome of the victim.

AGONAL PHASE IN HANGING:

In journal of forensic sciences, article was published regarding the process of death occur during hanging that is agonal phase. From that they postulated that the victim goes for unconscious within 13 seconds, convulsion started from 15 seconds onwards, decortication rigidity after 21 seconds, decerebration rigidity started after 46 seconds, again there is a second phase of decortication rigidity usually after a 1 min 11 seconds, loss of muscle tone after period of 1 min 38 seconds and at the last there will be isolated muscle movements after 4 min 10 seconds. In concern to the respiratory responses after hanging, there will be very deep respiratory movements started at 20 seconds. After the deep effort of respiration, the inspiratory and expiratory efforts slowly decreases and totally stopped after 2 min.

Generally the deceased is conscious only for a few seconds but it may extend to variable period of time depending upon the various factors like individual variation, type of hanging, position of hanging. Pathological studies and most of the survivors after hanging are describing that loss of consciousness appear within 8 to 10 seconds due to the decreased flow of blood to the brain or it may last for minute. After escaped from judicial hanging, few victims were clearly said, that they were in state of consciousness during the period of convulsion and they felt like body kicking, fighting and experienced the effect of suffocation, but this is a rare entity and considered as

exception when compared to the normal phenomenon. Due to lack of oxygen the vision get impaired resulting in a “blackout” followed by the loss of consciousness. But certain suicidal cases reported that the victim initially lose the consciousness and again return to the consciousness, suffering a lot from the effects of hanging during that period of consciousness. But the mechanism for the above occurrence is uncertain. Even the patient lose the control over the bladder, this occur around the period of time when there is loss of consciousness, mostly just before loss of consciousness.The loss of bladder control can be identified, by seeing the urine trickled down the whole pant, suggesting that the person was standing while he loses his bladder control. From that we come to a conclusion that the loss of bladder control appears just before losing his consciousness, because if it happens after the victim get unconscious means, the pant will not have long track of urination instead of only shorter track will be present.

CONVULSIVE PHASE:

This phase starts about 45 seconds after the victim hanged. When the pain of suffocation become unbearable, then the victim goes with the true convulsions that is when the carbon dioxide become overloaded, then the brain sense it and will send nerve signals without any much coordination.

Before the convulsions start, initially there will be heaving of the chest when attempted to breathe against the obstruction and the intensity of the

heaving increased rapidly. Heaving of the chest is mainly because of increased respiratory effort against the closed airway. One person who witnessed a hanging of women, mentioned that she was in hysterical laughter, by seeing the rapid jerking of her shoulder and chest. After this, rapid jerking movement is followed by the whole body convulsions. The convulsions can be in any form, and sometimes all the form of convulsion can be seen in a single individual.

In one form there will be a violent spasm of all the muscles, so the body starts to vibrate violently, then extending in very rapid spasms. This violent movement can be noticed in case of judicial hanging the person sometimes will not be visible as he is below the trap door because of the violent rapid spasm which occur after a period of 45 seconds.

Another form is tonic clonic seizure in which there is no rapid violent spasm, the muscles get locked up simply without further movements. In this case the legs get locked in the center and remain in that position for some time. One more interesting form of convulsion is the legs started jerking and kicking rapidly, both the legs can be involved together or single leg involved at a time separately this phenomenon is known as ‘Tyburn jig’. In seventeenth century during the executions, because of the jerky and kicky movements the musician used to play with the victims. Another example is that the Nazi prisons guards

were hanged and their feet were tied together so when a jerky movements occur both the legs moved together.

The last stage in convulsive movements is tightening of all the body muscles to a higher degree. Since the muscles on the back of the body and on the legs are very stronger when compared to other muscles in the human body, the victim get bend backwards during this stage. Some of them who witnessed the judicial hanging described in some cases the deceased heels almost touches the back side of their head. Photographic evidence also there for a person who died laying sideways, in this there is not total bend, still the bend maintains a semicircle position. Suppose the hands of the victims are tied in the front, usually the hands will be pulled upward till the mid chest during this stage, will return to its original down position after the convulsive stage ends.

During the end of the convulsive period mostly the victim loses his bowel control but not always. This is because tightening of the abdominal muscles during the convulsive stage, pushes the feces through the bowel while the bladder loses its control so earlier. Because of this in those days while executing the individual using hanging, the legs are tied together to avoid splitting of the feces all over the surfaces.

The duration of the convulsion in case of hanging is variable, it is not the same duration in all individual. Reports from the judicial hanging are there

which indicates that the average duration of period for the stage of convulsions is around 10 minutes. In some cases the stage will be for only three minutes and in some cases it can be extended up to twenty minutes. The particular reason for variation of time duration of convulsive episodes are not known. In some cases the person dies without any convulsive movements or only a few struggle of movements.

Finally the victim's body get relaxed, the legs and arms are relaxed and comes to original position. His toes extended and touches the ground level again, the toe comes to position, like that in before the process of convulsive phase. Now the entire area where the hanging is executed become silent, even no creak sounds of rope. The hangman used to check the duration of time, after 45 minutes of time he will cut down the rope. Usually the hangman, leave the person who hanged, for some time without any disturbances until they seems dead. After certain period of time doctors are appointed to declare the death, they usually check for the heart beats, if there is no heart beat the doctor will declare as dead.

Sometimes there will be no agonal phase at all and person die quietly without much effort. One of the important reason for the silent death in case of hanging is due to the vagal nerve stimulated which inhibit the cardiac beat directly by the ligature touches the carotid body or indirectly it senses the high blood pressure in the neck. And important thing is always individual variation

will be there in any matter, like that in hanging there will individual variation regarding the agonal phase.

Factors affecting the duration of agonal phase depends upon various entity which includes,

a. Type of hanging.
b. Ischemic Habituation.
c. Ethanol intoxication.

There is no difference in the duration of agonal period depending upon the suspension of the body, even the body touches the ground as in case of incomplete hanging also there will be agonal phase. In partial hanging there will be no gross differences for the agonal phase.

The autoerotic practitioners will develop a faster deep abdominal respiratory movements. The muscle tone will not reduce earlier, there will be delay in relaxation period. The agonal phase is similar in between the autoerotic and non-autoerotic groups, except the above mentioned two variables, deep abdominal respiratory movements and the muscle tone.

The ethanol intoxicated person will die earlier compare to the non-intoxicated persons. The duration of the agonal period will be very less in ethanol intoxicated persons because of, may be that ethanol is a respiratory depressants. There are no animal or human studies regarding this role of

ethanol intoxication on the timing of the agonal responses to support this theory. **Boghossian et al** proposed previously to do the study on the animals regarding the role of ethanol intoxication compared with the timing of agonal responses to hanging[62].

If the agonal period gets prolonged then there will be bowel wall hemorrhage and hemorrhage on to the anterior aspect of the intervertebral disc named as “Simon’s bleeding”. After the compression of the neck structures, there will be definite blood flow to the abdominal viscera. 28 percent of the stroke volume is maintained for the visceral perfusion. There will be increased pressure gradient between the artery and vein in the ratio of 1:10 resulting in the post capillary congestion leads to bowel wall hemorrhage. The mechanism for bowel wall hemorrhage can also be explained by the bowel wall spasms which occurs due to vegetative decoupling of the autonomic nervous system during the process of hanging. One more mechanism is the release of catecholamine which leads to the increased systemic hypertension with long pulse pressure which produces hemorrhage on the bowel wall. The above said mechanism is possible only when there is long agonal phase, because then only there will be enough time to produce these sign.

Simons bleeding is a condition in which there is bleeding on to the anterior aspect of the intervertebral disc, cannot penetrate the vertebral bodies. During the agonal phase there is lateral stimulation of the lumbar spine which

causes the rupture of vessel of spinal tract a branch from the lumbar vessel, which forms the characteristics Simons bleeding. The traction of the body in case of hanging also contribute to the Simon's bleeding.

POST MORTEM FINDINGS:

EXTERNAL FEATURES:

To prove the hanging as antemortem in nature is a difficult in many situations as there will be no positive findings and more ever no one is definite sign to say it as antemortem in nature. So we have to analyses all the evidences, scene of crime, some of the post mortem findings to give opinion as antemortem nature. Sometimes only single finding help us to give opinion regarding the hanging whether it is antemortem or postmortem. The following are important findings which may or may not be present in all the cases, they are;

1. Dribbling of the saliva.
2. Le facie sympathique.
3. Conjunctivae hemorrhages.
4. Protrusion of the tongue.
5. Ligature mark.
6. Facial congestion or pallor.
7. Petechial hemorrhage over the face.
8. Cyanosis of the fingernails.
9. Erection of penis.

Dribbling of saliva can occur in almost all cases but not always occurs, which is one of the important sign which indicates that the person was alive during the suspension of the body. Most of the book says it is one of the surest sign of antemortem hanging, though only one sign cannot be considered to be very effective to come to a conclusion.The absence of increased salivation cannot exclude the antemortem nature of hanging.

The dribbling of the saliva occur due to the irritation of the submandibular glands by the pressure of the ligature material during suspension. The increased salivary secretions will not occur if there is direct pressure alone to the gland as in manual strangulation, for the occurrence of dribbling of saliva there should be continuous and constant irritation of the glands.Due to stimulation of the pterygopalatine ganglion there will be increased salivation. The dribbling of the saliva is not present among all the cases as it is produced due to stimulation of the salivary glands by the ligature material, in case of partial hanging force acting on it will be less and there is no irritation of the glands. Mostly the saliva stains on the clothes and it becomes stiffen where the saliva stains. The scene of crime should be visited to have look for dribbling of saliva on the ground, sometimes stain appear as white color on the angle of the mouth itself. The saliva when it gets dried, it is fixed to the body or the clothes and becomes very difficult to remove the stain from the surface.

From the dribbling of the saliva we can able to find out the type of the hanging whether it is complete or incomplete (partial) and typical or atypical. In complete hanging the saliva dribbled on to the chest and sometimes to the ground just below the feet. In case of partial hanging the dribbling of saliva depends upon the various position, in prone position it should be in front of the person, in sitting position it is on to the chest, lying down position it will stain backwards from the mouth to the mandible.

In typical hanging that is knot on the back of the nape of the neck where the saliva dribbled through the middle of the lips. When the knot is on the left side, the dribbling of the saliva will be usually through the right side of the angle of the mouth. If it is on right side of the neck the saliva dribbled through the left side of angle of mouth. If suppose the knot is on the submentum then the dribbling will be present on both the angles of the mouth. Regarding the salivary dribbling **Ashok Kumarsamantha et al** mentioned that they were present in 32.31 percent of cases[63]. **Sarangi M.P.** described 11 percentage of the cases having salivary dribbling and not present in ligature strangulation even in single case[64]. **Paliwal P K et al** with the help of the police officers given cause of death in a mystery of death, he mentioned that drop on the lower lip which is salivary dribbling is antemortem in nature[65].

LE FACIE SYMPATHIQUE:

This is a condition in which there is opening of the eyelid along with dilatation of the pupil on the side where there is more compression of the neck structures by the ligature. This phenomenon is due to the stimulation of the cervical sympathetic chain. When there is unequal distribution of force, the cervical sympathetic chain on the side where more force distributed are stimulated resulting in the above said phenomenon.

If knot is on the right side more pressure will be distributed to the left side of neck resulting in le facie sympathique on the left side and vice versa can be true. This is one of the important sign of antemortem hanging, as the activation of the nerve occur only when the person alive during the suspension of the bodynot after the death of the person. But le facie sympathique is not present in all the cases, because the force or pressure on the neck structures is not uniform among all the cases.

LIGATURE MARK:

The ligature mark is an abrasion produced by the pressure on the neck by the materials used for hanging. This is a type of pressure abrasions. The ligature abrasion is a dry, furrow or groove, which is pale initially and become yellow or brownish yellow, the area become rough parchment like due to the drying of the skin. The ligature mark will be usually above the level of the thyroid cartilage, which is incomplete asymmetrical oblique in nature. In

exception to this there will be transverse complete symmetrical ligature mark in case of slip knot, where the ligature completely encircles the neck. In case of fixed loop the ligature mark will be obliquely upwards towards the suspension point. If the knot is on the back of neck then the ligature will be transverse on the front of the neck and obliquely upwards on the back of neck and there will be no mark at the position of the knot, the pattern of ligature mark will be more marked on the front side rather than the back due to inclination of the head forwards. If the knot is on behind the ear, the ligature mark will be marked on the side opposite to the knot, it will be transverse on the opposite side of knot and oblique on the side where the knot is fixed. If the knot is on the front of the neck the ligature mark will be around the neck on both the sides except the area below the chin, it will be more transverse on back of the nape of neck and less marked on the front sides. The ligature mark will be usually inverted V shaped on the side where the knot is fixed. Sometimes the knot may abrade over the skin due to the friction and produce an abrasion. In case of running noose, if the noose completely tightens the neck then the finding will be transverse ligature mark, or else if the noose is fixed then the pattern will be same as the case of fixed knot. In case of partial hanging where the body lean forwards possibilities are there for the occurrence of transverse ligature mark.

The ligature mark usually present above the level of thyroid cartilage because the weight of the body pulled downwards so the ligature moved upwards. But in case of partial hanging with low suspension point the mark may be present at the level of thyroid cartilage. Usually there is single abrasion but sometime due to slippage of the ligature from the original position there may be two ligature abrasion. Sometimes victim put two or more loop to confuse others or to mimic it as a homicidal in nature could happen. The ligature abrasion along with hemorrhages above or below the ligature contributes to the antemortem hanging, whereas hemorrhage alone cannot consider as sign of antemortem hanging. The width of the ligature abrasion is usually less than that of the width of the ligature used[66]. After drying for several hours only the pattern of the ligature is clearly visible. The skin and tissues beneath the abrasion should be checked for vital reactions, as reactions are one of antemortem sign of hanging. The gap in the ligature abrasion usually indicate the position of the knot.

According to **Gordon et al,** the absence of vital reactions cannot exclude the possibility of antemortem hanging. Sometimes ligature mark may not be present if cloth is folded in between the skin and the ligature or victim is having beard. In case of non-availability of used ligature material, the mark should be taped with plaster, take it out and look for the fibres attached to the plaster.

The periligature injuries play important role in the fixation of hanging as antemortem or postmortem or ligature strangulation. The rope burns or abrasion around the ligature mark appears during antemortem. The rope burns is due to friction of skin by the ligature which produces a considerable heat[67]. Blister will be formed in rope burns due to transudation of fluid into the outer layer of the skin indicating the antemortem nature of hanging. The nail marks on the skin may be produced by the individual itself due to the reflex action to preserve their own life[68]. Sometimes nails marks can be produced by the relatives who rescue the victims[69]. When the nail marks alone present it may be due to the manual throttling, but when the nail mark present along with the ligature mark it is very difficult to say the manner of hanging unless there is gross injuries to the neck inner structures. In case of ligature strangulation the nail marks will be multiple, deep, contusion over the soft tissues and deeper structures[70]. The nail marks present near to the ligature, irregular, vertical, crescentic in nature, are suggestive of ligature strangulation[71].

The other important thing to consider is the ligature mark cannot be seen in all the cases of antemortem hanging, its appearance on a particular individual depends upon the number of factors. The ligature mark on the skin of the neck depends upon

a) Composition of the ligature –depending on the composition, the pattern and texture of the ligature,it will reproduce on the skin by means of patterned abrasions. If suppose the thick rope is used it will reproduce its pattern on the neck. But the soft and material will not reproduce the same.

b) Width and multiplicity of the ligature – if the width of the material used is narrow then the furrow will be very deeper because of the force acting on that area will be increased. But if the width is broader like in sari, Dhuppatta the force will spread all over the width of the material and there will be only the superficial ligature abrasion not the deeper one.

c) Weight of the victim's body and the degree of suspension – large weight along with the greater degree of suspension will easily reproduce the ligature.

d) Tightness of the encircled ligature – the point opposite to the knot will usually tightened as the head inclined towards that side, the opposite side will be less marked.

e) Length of the time body suspended in hanging position – if the body suspended for very long period, the groove will be very deeper. Even the softer broader material suspended for longer period will produce ligature

mark. But if softer material used and the victim suspended only for shorter duration then there will be no ligature abrasion at all.

f) Position of the knot – the ligature abrasion will be maximum at the side opposite to the knot or opposite to the point of suspension.

g) Slippage of the ligature during suspension – the movement is there at the place of knot producing abrasion. The movement of the material is prevented by the jaw. If two ligature abrasion produced due to the slippage of the ligature, the first one will be minimal and lower level connected to the final one which is at the upper level with clear abrasions.

The ligature mark on the neck also one of the important sign of antemortem hanging. But still, even after death that is during peri mortem period also the ligature mark can be reproduced. When taking the ligature mark into the account we have to give consideration to all other antemortem features. The ligature mark may be absent if ligature applied on the heavy beard, clothes. The jewels, tight clothes in the putrefied body stimulate like ligature mark which should be avoided by using other evidences.

SUB CONJUNCTIVAE PETECHIAL HEMORRHAGE:

The petechial hemorrhage over the face, conjunctivae, and mucosal surfaces of the internal organs can occur in hanging.The mechanism for the

petechial hemorrhage still in debate whether it is arterial or venous rupture, and whether it is feature of asphyxia or obstruction of the venous system. And one more thing the petechial hemorrhage is not specific for the asphyxia alone, it can occur in lot of conditions other than the hypoxia. Some of the authors of opinion that in other cause of death also, petechial hemorrhage is due to the hypoxic episodes they developed, just before the end of their life.

Tardieu was the first person who mentioned about the pin point petechial hemorrhage, he said it is due to rupture of small blood vessels on the surface of internal organs as result of asphyxia. But still confusion is there regarding the cause and mechanism of petechial hemorrhage. But nowadays the Tardieu spotsare refers to the rupture of the engorgement of the vessels on the dependent area, where intense lividity is present, not due to asphyxia or any other mechanism of death.

Luke was the first person who described that petechial hemorrhage was due to increased intracranial pressure due to the obstruction of the neck structures. He mentioned that the increased gradient between the artery and the venous is the responsible for the occurrence of hemorrhage. Obstruction of the venous channel alone results in continuous flow through the artery but no drainage to the heart resulting in increased gradient between the artery and venous which cause the petechial hemorrhage[72].

In 1985 Luke and his colleague conducted study on petechial hemorrhage in hanging cases and come to a conclusion that small vessel and intra capillary blood pressure in the face lead to the formation of pin point hemorrhage which is depend upon the degree of obstruction of the carotid and vertebral artery[73]. Other author supported Luke theory, but some of them added that along with increased venous pressure, combined effect of hypoxic injury to the endothelial cell also contributed to the formation of petechiae.

Rao and Welti described that the petechial hemorrhage in non-asphyxia cases due to the increased venous pressure in the cranium without any obstruction to the neck or chest[74]. He included acute right heart failure will cause petechial hemorrhage over the heart due to the elevated cephalic venous pressure. One more fact that added support to the mechanical theory, for the formation of petechiae is that they are more likely involved on the conjunctivae and eyelids when observed on the head[75]. There are lot of non-asphyxia causes also there which leads to petechial hemorrhage on the conjunctivae, they are

a) Status epileptics.
b) Bronchial asthma.
c) Labor and delivery.
d) Violent coughing, sneezing, vomiting.
e) Dying at prone position.

f) Right heart failure.

g) Respiratory stridor.

The best example to say that hypoxia has no role in the production of conjunctivae petechial hemorrhage is, in case of asphyxial death like gagging, any forms of smothering, choking, over laying of the children, plastic bag suffocation, entrapment, drowning[76], there will be no petechial hemorrhage at all.

Luke in his studies noted that the conjunctivae hemorrhage as the single findings in many cases and the facial skin hemorrhage if present, never without the conjunctivae hemorrhage. The mechanism for the occurrence over the conjunctivae is due to the lack of support and resistance offered by the connective tissues.The petechial hemorrhages is present not only on the sub conjunctivae but also in the mucosa of lips, eyelids, face, and scalp.

From the above mentioned theories, the sub conjunctivae hemorrhage is due to the increased cephalic vascular pressure due to both the obstruction of the neck and without obstruction also, but there is doubt on that the hypoxia can produce hemorrhage or not. The petechial hemorrhage is not present in all the cases of hanging. In case of complete hanging by a heavy weight person there will be obstruction of artery, resulting in no increased gradient between the artery and the venous and no sub conjunctiva hemorrhage. In partial

hanging it is more marked due to the obstruction of venous with patent arterial flow. Thus the petechial hemorrhage is not the specific finding for antemortem hanging as it can occur in other causes also, but can be taken as a finding if specific features of hanging is present in that particular case.

CONGESTION OF FACE:

It occurs because of obstruction of the venous channel present over the neck, without the obstruction of the arterial flow. Due to continuous arterial flow there will be increased blood flow to the brain but because of the obstruction of the jugular, drainage to the heart is affected resulting in the edema or congestion of the tissues above the level of obstruction. Due to the elevated venous pressure in case of hanging there will be transudation of fluid in to the tissues resulting in edematous face. Congestion of face is more marked when the death is delayed for a prolonged period as in the case of partial hanging. In complete hanging, if the death is immediate then there will be no congestion of face. The congestion of face is more marked in case of ligature strangulation, as in that there is mostly venous obstruction only, and the obstruction continues till the victim dies. The face will be pale in case of hanging where the death is due to vagal inhibition. The congestion of face is not the specific feature of hanging and in many occasions it is absent. It is one of the differentiating feature of hanging from the ligature strangulation.

CYANOSIS:

Due to decreased oxygen supply because of asphyxia there will bluish discoloration of the finger nails, mucosal surface of lips, nose, cheeks, and tongue. The cyanosis is not marked in case of immediate death. If process of death is prolonged then there is enough time for the formation of deoxy hemoglobin in the blood leads to cyanosis. Cyanosis could not be considered as a specific finding of hanging. As the cyanosis is evident in all the cases where there is decreased oxygen supply, they cannot taken as a specific feature for ante mortem hanging. Cyanosis can occur in the following conditions.

I) Intracranial hemorrhage.

II) Seizure disorder.

III) Heroine over usage.

IV) Pneumonia.

V) Bronchial asthma.

VI) Bronchiolitis.

VII) Pulmonary hypertension.

VIII) Hypoventilation.

IX) COPD.

X) Myocardial infarction.

XI) Congenital heart diseases.

XII) Methemoglobinemia, polycythemia.

XIII) Arterial obstruction (peripheral vascular disease).

XIV) Venous obstruction (deep vein thrombosis).

The cyanosis is evident when the deoxy hemoglobin in the blood raises to 5 g/dl. In Methemoglobinemia even the arterial oxygen level maintains in a normal range, there will be features of cyanosis. So cyanosis can be produced in any of the above mentioned conditions. It cannot be consider as a specific finding antemortem hanging alone.

OTHER FEATURES:

Due to pressure on the base of the tongue, posterior aspect of the pharynx, pushing of the larynx upward by the ligature, there will be protrusion of tongue. Protrusion of tongue can be seen in decomposed bodies also due to generalized distension with gas. The tongue is usually blue in color and swollen at the base. The protruded part become dark brown or black in color due to effect of drying in the atmospheric air.

Erection of the penis occurs as a postmortem phenomenon due to the effect of hypostasis. Erection of penis is associated with ejaculation of semen at the tip or prostatic secretions or passage of urine. Violent death like judicial hanging, gunshot injuries result in the post mortem erection of the penis. In females there will be engorgement of the clitoris, discharge of blood from the vagina[77]. In males there will be complete erection or semi erection of the penis.

INTERNAL FINDINGS:

The ligature abrasion on dissection it appears as dry, pale, clear due to the action of axial traction on the body weight. There will be minimal hemorrhages around the ligature mark. Sometimes minimal bleeding into the soft tissues will be there without affecting the muscles. It is very difficult to say the antemortem nature of hanging by ligature mark as it was produced even after death during peri mortem period. The ligature mark also present in case of strangulation, the doctor who conducting the autopsy should decide the nature from various circumferential evidences.The fracture of hyoid bone can occur sometimes in hanging. But it is not the characteristic sign of antemortem hanging as it can occur during postmortem due to handling of the body. Moreover the hyoid bone fracture is more common among the manual throttling cases compared to the hanging. In a Study conducted by **TRIBUDE B H ET AL**[78], the fracture of hyoid bone was 64.51% which was the maximum percentage when compared to the other studies, **CHORMUNGE PATIL ET AL**[79] (7.14%), **SARANGHI ET AL** (9.4%),**SHEIKH M I ET AL**[80] (5.08%) cases and **MEERA ET AL**[81] (3.57). The fracture of hyoid bone in hanging will be outward in nature when compared to the inward fracture in throttling. The fracture of thyroid cartilage also occur in certain cases of hanging, but the cricoid fracture is rare. The cervical vertebrae fracture can occur in hanging, depends upon the length of the drop. If long drop used then

there are more chances for the occurrence of fracture. This is associated with the transection of spinal cord at the level of fracture due to the dislocation of the vertebrae. The brainstem also affected at the same time leads to sudden death.

The brain may appear as pale or congested depending upon the obstruction of the vascular structures. If the jugular alone obstructed then there will be congested brain. If the obstruction extends to carotid also then there will no blood to the cranium, so the brain will be pale in nature. The vasovagal inhibition in hanging leads to sudden death within seconds, so the brain will be normal in appearance. The internal organs will be congested in almost all the cases, due to altered autonomic system and increased gradient between the artery and the veins.

Petechial hemorrhage can occur all over the mucosal surfaces of the internal organs. As already mentioned that petechial hemorrhage can be due to capillary rupture as result of asphyxia or venules rupture due to the obstruction of the jugular system. The petechial hemorrhages seen mainly on the pericardial surfaces of heart, inter lobar fissure of the lungs, outer surface of the kidney.

The above mentioned features are not the definite sign to conclude the hanging as antemortem in nature. The presence of bowel wall hemorrhages,

bleeding onto the anterior surface of intervertebral disc, rectal bleeding added more value to say it as antemortem hanging.

BOWEL WALL HEMORRHAGE:

Bowel wall hemorrhage can occur in case of hanging, there are variety of mechanisms postulated for bowel wall hemorrhage in hanging. As there is no definite sign for antemortem hanging, this one will increase the value for hanging to say it as antemortem in nature. Study to support the bowel hemorrhage is rare, long back literature was given by **Maxiener (1993)** regarding the bowel wall hemorrhage in strangulation and throttling, but he described that the cause for the above is mechanical trauma as it happened always in homicidal victims. But after this literature, many cases of bowel wall hemorrhage reported in hanging, so **Friedrich Schulz** along with his coworker conducted a retrospective analysis of hanging cases during the period of 2005 to 2009. They postulated the different mechanism for the occurrence of bowel wall hemorrhage in hanging cases. The differential diagnosis for the presence of bowel wall hemorrhage and that should be ruled out are included in the following

a.) Putrefactive changes.

b.) Infarction or ischemic related hemorrhages.

c.) Congenital clotting disorders.

d.) Acquired clotting disorder (DIC, sepsis).

e.) Hypothermia related hemorrhage.

In infarction or ischemia to the bowel wall the primary lesion is ischemia due to which secondary hemorrhages can occur in which the mucosal involvement is the earliest[82]. But in the hanging hemorrhages occur due to acute circulatory dysregulation does not involve the mucosal layer[83], serosa hemorrhage is most common but the reason is not understood.

In complete occlusion of the carotid, there is cerebral hypoxia which leads to decreased respiratory perfusion, which prevents the rise in the carbon dioxide level that is necessary for respiration. The result of which is sudden respiratory arrest followed by loss of consciousness within few seconds[84, 85]. But the heart still beat for a period of 7 to 20 minutes or even longer has been evidenced by the authors in cases of judicial hanging[86, 87, 88]. During the agonal period initially there will be bradycardia and the forceful contractions of the heart which is followed by the increased heart beat and finally cardiac arrest[89].

When the jugular system alone obstructed without the occlusion to the carotid, there will be increased intracranial pressure with resultant decoupling of the systemic blood pressure and altered autonomic nervous system due to hypoxia. So during long agonal phase there will be alteration in the blood pressures and heart rate due to the hypoxemia and acute circulatory dysregulation.

In hanging the blood flow to the abdominal organ is preserved, 28% of the stroke volume is used to perfuse the organs. Due to the alteration in the circulation, there will be increased pressure gradient between the venous and arterial beds and the blood supply is regulated by the autonomic nervous system (vasomotor reactions of small arteries)[90]. In addition to the post capillary congestion, during hanging there is bowel spasm due to vegetative decoupling of the sympathetic and parasympathetic nervous system that also explain the bowel wall hemorrhage in hanging.

There is report on increased catecholamine's observed in hanging. Catecholamine increase the blood pressure and cause gastro enteral congestion, in the presence of bradycardia with long pulse pressure resulting in heart failure and longer duration of agonal phase in hanging[91]. The increased catecholamine even affect the heart, this can be evident from the recent report that was conducted in case victims who survived after attempted suicide, described left ventricular dysfunction due to catecholamine[92]. So the systemic hypertension through the increased catecholamine's along with the anoxic decoupling of the left and right side of the heart could explain the bowel wall hemorrhage due to post capillary congestion.

The bowel wall hemorrhage can be anywhere on the bowel including both small and large bowel. The presence of bowel hemorrhage could be confirmed by the histopathological examination of the segments of the bowel.

In some cases rectal wall hemorrhage can also be present, but its specificity for antemortem hanging is very less. In a prospective study regarding the rectal wall hemorrhage and hanging, they described that hypostatic hemorrhages during postmortem can form due to the increased gravitational hydrostatic pressure in the venous plexus which started on autolysis. Due to accumulation of blood in the venous system the pressure get increased which leads to the leaking of blood through the autolysing vessel wall[93]. For the development of the hypostatic hemorrhage extensively, rich venous network with complicated anastomoses of thin walled vascular channels which is not supported by the extravascular connective tissues is needed. The above said vascular networks are pharyngeal plexus found in the neck, pelvic organs including hemorroidal plexus, and the meningorachidian plexus in the epidural space[94].Even histology cannot differentiate whether it is antemortem or postmortem, so rectal wall hemorrhage cannot be considered as a valuable sign for the antemortem hanging.

Simons bleeding is a condition in which there is bleeding into the anterior aspect of the intervertebral discs. Most commonly lumbar region involved, other vertebrae also involved sometimes. It was first described in the year 1968 by the German forensic pathologist named **ALEX SIMON** in the cases of hanging[95, 96]. The bleeding occur only on to the anterior aspect of the intervertebral disc, they will not penetrate into the vertebral bodies. Simons

bleeding can occur in other conditions other than the death due to hanging. The differential diagnosis for Simons bleeding included the following

a) Hanging.
b) Road traffic accidents.
c) Fall from a height.
d) Drowning.
e) Hypothermia.

The occurrence of Simon's bleeding in cases of natural diseases are very rare phenomenon[97]. But if the corpse is started to decompose, even using histology it is very difficult to distinguish Simons bleeding from putrefaction. In 1968 study conducted by the Alex Simon 53 cases showed typical hemorrhage into the anterior aspect of the intervertebral discs out of 64 cases.

Geserick et al reported nearly of about 29.2% of cases with Simons bleeding among the 840 cases of death due to hanging which was analyzed retrospectively[98, 99]. **Kleiber et al** reported Simon's bleeding in 47 percent of the cases among 222 cases[100]. **Saternus** noted 56 percentage of the cases among the 32 cases showed bleeding into the anterior aspect of anterior longitudinal ligament[101]. During postmortem experiments on hanging cases, Simons bleeding could not be able to reproduce on the lumbar vertebrae, it clearly shows it is valuable sign for antemortem hanging[102].

Simons had an idea that the hemorrhages were results of overstretch of the spine due to complete suspension of the body. Many study conducted later confirmed it. Even though more number of cases have been noted during complete suspension of the body, cases have been noted for incomplete suspension of the body also but less frequently[103]. So it is obvious from the above statement complete suspension of the body play a major role in the formation of Simon's bleeding.

The hemorrhages are influenced by the degenerative changes of the spine especially among the elderly, where the occurrence of Simon's bleeding is less frequent due to increased rigidity of the vertebrae. The degenerative disease of the spine of lumbar region, mainly of osteophytes or deformation of the vertebral bodies, leads to increased rigidity of the spine, which limits the overextension of the spine because of that there is no hemorrhages seen over the anterior aspect of the intervertebral discs. Simons conducted autopsy to a young couple newly married, case of hanging with free suspension of both the body in the air. The girl was positive for features of Simons bleeding, but her husband did not showed the hemorrhages. On further dissection he came to know that the boy had degenerative changes in the spine and Simon reported that degenerative changes of the spine would prevent the formation of hemorrhages due to increased rigidity.

Agonal convulsions start soon after the person hanged himself in suicidal hanging[104, 105]. During this convulsions there will be forceful or violent movements in the lumbar region of the spine. Agonal convulsion is followed by the decorticate rigidity, with lateral extension of lower limbs and trunk. This kind of movements results in the rupture of vessels of the spinal tract of 'lumbar artery' due to violent stimulation of the lumbar vertebrae. The one more important factor which contributes to the bleeding is traction of the body due to the gravity force. The occurrence of Simons bleeding in other unnatural death is very rare, most often due to hyperextension against the spine[106]. In cervical spine also these hemorrhages described in positional asphyxia cases[107]. Simons bleeding is one of the important sign for antemortem hanging, but its absence cannot exclude the possibility of death due to hanging. It has its significant value when there is minimal findings on the cervical organs.

Thus there is no specific sign for antemortem hanging, we are going to add the value for the antemortem hanging by correlating the bowel wall hemorrhage with the other valuable signs. The absence of it's could not rule out the antemortem in nature. But its presence add a more value to the hanging to be in antemortem in nature.

Materials & Methods

MATERIALS AND METHODS

This prospective study was conducted in the Institute of Forensic Medicine, Madras Medical College, Chennai-3 for a period of 10 months.

This study is conducted to find the incidence of bowel wall hemorrhage in cases of hanging subjected for autopsy within 36 hours, to correlate the bowel wall hemorrhage with the antemortem hanging and correlate the bowel wall hemorrhage with the Simon's bleeding. All cases of hanging from the period of 8thApril2014 are included in the study excluding the exclusion criteria which is given below. Before conducting the study, Institutional Ethical committee approval was obtained.

In dead bodies with history of hanging antemortem are subjected for autopsy. Detailed history regarding the case has been obtained, External examinations done, cyanosis, petechial hemorrhage, or any other injury examined carefully. After the external examination, the body dissected as per the protocol of post mortem examination, after dissecting into the thorax, the lungs, heart are examined for the features of congestion, petechial hemorrhages carefully. Next the abdominal cavity examined, the loops of bowel wall both the small and large bowel examined for external hemorrhages. The areas which shows the hemorrhage sent for the histopathological examination to confirm the presence of hemorrhage. After dissecting all the

organs the vertebral body are examined for the presence of hemorrhage beneath the intervertebral disc. The ligature abrasion examine for the minimal hemorrhages around the mark, then finally neck dissected and examined for the hemorrhages, injury to the muscle, hyoid bone fracture, thyroid cartilage fracture.

SUBJECT SELECTION:

The prospective study was conducted on hanging cases coming for Medico Legal autopsy to the Institute of Forensic Medicine, Madras Medical College, Chennai-3.

INCLUSION CRITERIA:

1. All dead bodies with history of hanging subjected for autopsy within 36 hours of death.

EXCLUSION CRITERIA:

1. All dead bodies subjected for autopsy after 36 hours of death or which shows signs of putrefaction.
2. All dead bodies subjected for autopsy diagnosed to have septicemia, abdominal surgery, DIC, bleeding disorders, abdominal trauma, and chronic intestinal diseases.

The internal autopsy was followed by microscopic examination which is sent to the Institute of Pathology. The bowel wall hemorrhage should be correlate with the other ante mortem findings.There are various factors which affects the outcome of this study. The duration of hanging is the most important factor, as the long agonal phase of the individualis one of the cause for the mechanism of hemorrhage. But the duration of hanging is not exactly known, as the relatives are not aware when the deceased hanged himself, in certain cases they aware of the duration.

Analysis & results

ANALYSIS AND RESULTS

FREQUENCY TABLES SHOWING AGE DISTRIBUTION OF STUDY POPULATION (HANGING CASES)

AGE DISTRIBUTION	FREQUENCY	PERCENT
<20 yrs	4	10.5%
21-40 yrs	23	60.5%
41-60 yrs	8	21.1%
>60 yrs	3	7.9%
TOTAL	**38**	**100%**

In my study, the majority of population involved are between 21 – 40 age group, they contribute to 60.5% percentage of the study population. The younger age group <20 years and older age group >60 contribute less number of cases 10.5% and 7.9% respectively. The deceased involved between 41 – 60 age group are 21.1%.

PRESENCE OF BOWEL WALL HEMORRHAGE IN DIFFERENT AGE GROUPS

AGE GROUP	BOWEL WALL HAEMORRHAGE		TOTAL
	PRESENT	ABSENT	
<20 yrs	1(25%)	3(75%)	4
21-40 yrs	5(21.7%)	18(78.3%)	23
41-60 yrs	3(37.5%)	5 (62.5%)	8
>60 yrs	1(33%)	2(66%)	3
TOTAL	**10(26.3%)**	**28(73.7%)**	**38(100%)**

Chi square -0.845 df-3 p value – 0.82

In this study the presence of bowel wall hemorrhage in 41 to 60 age group is 37.5% which is the maximum, 3 cases with bowel wall hemorrhage out of 8. The age group between 21 – 40 years contribute to 5 (21.7%) cases with hemorrhage among 23 cases. Age <20 and >60 contributes each one case which constitutes 25% and 33% respectively.

FREQUENCY TABLES SHOWING SEX DISTRIBUTION OF STUDY POPULATION

SEX DISTRIBUTION	BOWEL WALL HEMORRHAGE		FREQUENCY	PERCENT
	Present	**Absent**		
Males	7(25%)	21(75%)	28	73.6%
Females	3(33.3%)	6(66.7%)	9	23.6%
Transgender	0(0%)	1(100%)	1	2.8%
TOTAL	**10**	**28**	**38**	**100%**

The total number of cases among the males are 73.6%, which is 28 cases among the total 38 cases. In this only 7 cases of hanging shows bowel wall hemorrhage out of 28 cases, 25% of males only showed bowel wall hemorrhage. The female population in this study group involves 23.6% which is 9 cases out of 38 cases and the remaining one case is transgender. But the 33.3% of females showed presence of bowel wall hemorrhage that is out of 9 cases 3 cases showed bowel wall hemorrhage.

FREQUENCY OF BOWEL WALL HEMORRHAGE AMONG THE STUDY SUBJECTS

BOWEL WALL HEMORRHAGE	FREQUENCY	PERCENT
YES	10	26.3%
NO	28	73.7%
TOTAL	**38**	**100%**

In my study among the 38 groups, the frequency of bowel wall hemorrhage is 26.3%, that is 10 cases showed bowel wall hemorrhage out of 38 cases. The remaining 73.7% of cases does not show any involvement of the hemorrhage on the bowel wall. Among the 10 cases which showed bowel wall hemorrhage, in 6 cases it is present on the jejunum which constitutes 60% of the total, in 3 cases it is present on the duodenum which is 30% of the total cases, only one case showed hemorrhage on the ileum.

FREQUENCY OF BOWEL WALL HAEMORRHAGEWITH THE TYPE OF HANGING

TYPE OF HANGING	BOWEL WALL HAEMORRHAGE		TOTAL	FREQUENCY
	PRESENT	ABSENT		
COMPLETE	5(25%)	15(75%)	20	52.6%
PARTIAL	5(27.8%)	13(72.2%)	18	47.4%
TOTAL	**10(26.3%)**	**28(73.7%)**	**38**	**100%**

Chi square -0.038 df-1 p value – 0.82

In my study 52.6% of cases are complete hanging, 47.4% cases are partial hanging. Out of 20 cases of complete hanging 5 cases showed bowel wall hemorrhage which constitutes 25%, so 25% cases in complete hanging the bowel wall hemorrhage is present, the remaining 75% cases of complete hanging does not show hemorrhagic involvement on the bowel. 27.8% cases of partial hangingshowed bowel wall hemorrhage, which is 5 cases out of 18 partial hanging cases.

FREQUENCY OF BOWEL WALL HAEMORRHAGEWITH RESPECT TO MATERIAL USED FOR HANGING

MATERIAL FOR HANGING	BOWEL WALL HAEMORRHAGE		TOTAL
	PRESENT	ABSENT	
SAREE	5(25%)	15(75%)	20(52.6%)
NYLON SAREE	1(20%)	4(80%)	5(13.2%)
DUPATTA	2(33.3%)	4(66.7%)	6(15.8%)
NYLON ROPE	1(16.7%)	5(83.3%)	6(15.8%)
ROPE	1(100%)	0	1(2.6%)
TOTAL	**10(26.3%)**	**28(73.7%)**	**38(100%)**

Chi square --3.31 df-4 p value – 0.447

In this materials used for hanging by most of the individual are saree which contributes 65.8% that is 25 cases out of 38, the remaining included dupatta which is 15.8% (6), nylon rope contributes 15.8% (6), and rope which involves in only one case that contributes 2.6%.

CORRELATION BETWEEN BOWEL WALL HAEMORRHAGEAND CYANOSIS

CYNANOSIS	BOWEL WALL HAEMORRHAGE		TOTAL
	PRESENT	ABSENT	
ABSENT	3(23.1%)	10(76.9%)	13(34.2%)
PRESENT	7(28%)	18 (72%)	25(65.8%)
TOTAL	**10(26.3%)**	**28(73.7%)**	**38(100%)**
Chi square – 0.017 df-1 p value – 0.714			

The total number of cyanosis present among 38 cases are 25 cases which constitutes 65.8% of the total. 34.2% cases hanging presented without any cyanosis that is 13 cases out of 38. In that total cyanosed cases 7(28%) cases are associated with bowel wall hemorrhage, the remaining 18(72%) cases out of 25 cyanosed cases with no bowel wall hemorrhage. 3 cases without cyanosis presented with bowel wall hemorrhage. The remaining 10 cases presented without cyanosis and without bowel wall hemorrhage.

CORRELATION BETWEEN THE PETECHIAL HEMORRHAGE AND BOWEL WALL HEMORRHAGE

PETECHIAL HEMORRHAGE	BOWEL WALL HAEMORRHAGE		TOTAL
	PRESENT	**ABSENT**	
ABSENT	1(16.7%)	5(83.3%)	6
IN LUNGS	4(28.6%)	10(71.4%)	14
HEARTS & LUNGS	5(27.8%)	13(72.2%)	18
TOTAL	**10(26.3%)**	**28(73.7%)**	**38(100%)**

Chi square -0.084 df-2 p value – 0.32

Petechial hemorrhage present in the lungs alone in 14 cases out of 38 cases which constitutes36.8% of total cases, in which 28.6% of the cases only showed bowel wall hemorrhage. In both heart and lungs it is present in 47.3% of the total cases in this 27.8% of cases only showed bowel wall hemorrhage.

FREQUENCY OF BOWEL WALL HAEMORRHAGEWITH RESPECT TO DURATION OF HANGING

DURATION OF HANGING	**BOWEL WALL HAEMORRHAGE**		**Total**
	PRESENT	**ABSENT**	
NOT EXACT	1(20%)	4(80%)	5
<5 MIN	0	7(100%)	7
5-10 MIN	4(26.7%)	11(73.3%)	15
>10 MIN	5(45.5%)	6(54.5%)	11
TOTAL	**10(26.3%)**	**28(73.7%)**	**38(100%)**
Chi square --4.61 df-3 p value – 0.197			

Bowel wall hemorrhage present in 26.7% when duration of hanging is 5 to 10 minutes that is 4 cases presented with hemorrhage out of 15. Bowel wall hemorrhage present in 45.5% of cases when the duration of hanging is greater 10 minutes, 5 cases presented with hemorrhage out of 11 cases. In one case with bowel wall hemorrhage exact time cannot be ascertained.

CORRELATION BETWEEN BOWEL WALL HEMORRHAGE AND HEMORRHAGE AROUND THE LIGATURE MARK

HEMORRHAGES AROUND THE LIGATURE MARK	**BOWEL WALL HAEMORRHAGE**		**TOTAL**
	PRESENT	**ABSENT**	
PRESENT	8(50%)	8(50%)	16(42.1)
ABSENT	2(9.1%)	20(90.9%)	22(57.9)
TOTAL	**10(26.3%)**	**28(73.7%)**	**38(100%)**

Chi square –7.99 df-1 p value – 0.005 Significant

Hemorrhages around the ligature mark are present in 16(42.1%) cases out of total 38 cases. 50% of the cases of hemorrhages around the ligature mark showed bowel wall hemorrhage(8 out of 16 cases). In the 22 cases which shows no hemorrhage around the ligature mark 2(9.1%) cases showed bowel wall hemorrhage. The remaining 20 cases shows neither hemorrhages around the ligature mark nor the bowel wall hemorrhage.

Discussion

DISCUSSION

In this study the incidence of bowel wall hemorrhage is 26.31 percentage which is higher when compared to the study conducted by Schulz who reported 12 % of incidence among hanging deaths during the period of 2005 to 2009 and another study conducted by the **OKAZI** who also reported similar 11.6 % incidence.This study is a prospective one analyzing all the relevant data, but the previous one by Schulz was a retrospective study[108]. In this study 10(26.31) cases are positive for bowel wall hemorrhage out of 38 cases. In that 10 cases bowel wall hemorrhage present in jejunum in 6(60%) cases, 3(30%) cases in duodenum, 1(10%) in ileum shows bowel wall hemorrhage.

The cases which cause the bowel wall hemorrhage other than the hanging like the DIC or sepsis[109], chronic intestinal diseases, bleeding disorders either acquired or congenital[110], mechanical trauma to the abdomen[111], corpses which showed signs of putrefaction, severe hypothermia[112] are excluded from my study.

Schulz postulated several mechanisms which are responsible for the bowel wall hemorrhage. One of it is acute circulatory dysregulation leads to the formation of bowel wall infarction results in serosal hemorrhage without affecting the mucosal layer. Second one islong duration of agonal phase leads

to dysregulation of circulation with fluctuating pulse and pressure which causes the bowel wall hemorrhage. The other mechanism is due to the systemic hypertension there is increased catecholamine's which results in the 'anoxic' decoupling of both the left and right heart.

In our study the incidence of bowel wall hemorrhage is common between the age group of 21 to 40, 50% of bowel wall hemorrhage cases belong to this age group. The reason for the occurrence among this group cannot be ascertained as the percentage of hanged person is most common among that age group in my study, they contribute around 60.5% of the study population. The younger age and the older age group people are lesser in number in my study that may be the reason for lesser occurrence among that age group. Schulz in his study postulated that, during the prolongation of the agonal phaseunderlying effects of cardio vascular disease among the older group leads to the formation of bowel wall hemorrhage. But in our study older age contribute lesser in number, so could not be able to ascertain the specific reason for the occurrence.

Bowel wall hemorrhage is present in 7 male cases out of 10 which contributes 70% percent of total bowel wall hemorrhage cases. Overall the most number of cases of bowel wall hemorrhage is present in male, as the male contributes to the more number of hanging cases. But the occurrence of bowel wall hemorrhage in total number of male is less compared to the

occurrence of bowel wall hemorrhage in total female cases, because 7(25%) cases in male has bowel wall hemorrhage out of 28 total male cases but female has 3(33.3%) bowel hemorrhage cases out of 9 cases. The remaining one case in this study is transgender.There is not much difference between male and female occurrence of bowel wall hemorrhage. This is similar to the previous study conducted by the Okazi.

Regarding the type of hanging there is no much difference in occurrence of bowel wall hemorrhage between complete and partial hanging. 52.6% of the cases are complete hanging, 47.4% of the cases are partial hanging. In this 25% of the complete hanging shows bowel wall hemorrhage and 27.8% of the partial hanging shows bowel wall hemorrhage. So the definite reason for the occurrence of bowel wall hemorrhage regarding the type of hanging cannot be found.

Most of the deceased used saree as a ligature material they contributes around 65.8% of the total cases. In the remaining 34.2% of the cases the ligature material used are rope, dupatta. Distribution of bowel wall hemorrhage among the various material used shows no significant difference. The increased use of saree shows that most of them hanged due to the impulse activity, as they used the readily available material.

In this study we compared bowel wall hemorrhage with cyanosis, there is no much difference between bowel wall hemorrhages in hanging cases with cyanosis and the hanging cases without cyanosis. Out of 25 cases of cyanosis, only 7 cases showed bowel wall hemorrhage, similarly out of 13 cases without cyanosis, only 3 cases showed bowel wall hemorrhage. The presence of bowel hemorrhage among the hanging cases with cyanosis and hanging cases without cyanosis are 28% and 23.1% respectively. Hence there is no much difference, even in the absence of cyanosis, bowel wall hemorrhage could be considered as one of the feature of antemortem hanging.

In our study the duration of hanging classified into <5 minutes, 5 to 10 minutes, >10 minutes, exact time not known. The variable greater than 10 minutes included when the deceased seen after a long period of time, mostly they died at the spot itself. 45.5% of the cases with duration of hanging >10 minutes showed hemorrhages, which is more when compared to 26.7% of the cases with duration of hanging between 5 to 10 minutes. This shows that in longer duration of hanging (prolonged agonal phase), there will be altered blood pressure mechanism in the blood vessels, the gradient between the artery and venous system altered to 1:10 ratio, increased catecholamine's which affect the blood pressure, all these mechanism are responsible for the occurrence of bowel wall hemorrhage. This was stated by Schulz in his study on bowel wall hemorrhage in hanging cases.

Ligature mark is considered as one of the vital sign for antemortem hanging but still it can be produced during the perimortem period (within 2 to 4 hours) of death. In this study out of 38 cases, almost 92.1 (35cases) percent of the cases developed incomplete oblique irregular well-formed ligature abrasion above the level of thyroid cartilage. Only one (2.6%) case with faint ligature abrasion above the level of the thyroid cartilage. Only 22.2% of the cases with ligature abrasion showed bowel wall hemorrhage. In two (5.3%) cases there is no ligature mark at all, but all the two cases without ligature abrasion showed bowel wall hemorrhage. One case using dupatta and another using saree does not produce any ligature abrasion, but the presence of bowel wall hemorrhage in that two cases is one of the important vital sign for antemortem hanging.

In our study 32 cases showed petechial hemorrhage on lungs and heart surfaces out of 38 cases. In that only 28.1% cases showed bowel wall hemorrhage. Remaining 71.9 percent of the cases does not show any involvement. One cases without petechial hemorrhage presented with bowel wall hemorrhage out of 6 cases without petechiae.

In hanging cases there will be minimal hemorrhages around the ligature mark. Hemorrhages seen above or below the ligature abrasion, in some cases it could be identified using microscope only. Ligature mark along with the

hemorrhages around it could be considered as one of the important vital sign rather than the ligature mark alone. In my study hemorrhages around the ligature mark present on the 42.1% of the cases, remaining 57.9% of the cases there is no hemorrhage anywhere around the ligature mark. 50% of the cases with hemorrhages around the ligature mark shows bowel wall hemorrhage in my study. 90.9% of the cases without the hemorrhages around the ligature mark does not show any hemorrhages on the bowel wall. But only 9.1% of the cases without hemorrhages around the ligature mark showed bowel wall hemorrhage. In that 2 cases also there is no ligature mark at all, this shows that there is significant correlation between the hemorrhages around the ligature mark and the bowel wall hemorrhage. By using chi square test for the correlation the p value is 0.005 which is a significant one.

In our study there is no case of hyoid bone fracture, thyroid cartilage fracture or hemorrhages and no cases of Simons bleeding that is bleeding into the anterior aspect of the intervertebral disc. So the above findings not able correlate with the bowel wall hemorrhage. Hyoid bone not always fractured in hanging cases, the pressure involvement, duration of suspension, material used and weight of the body are variable factor in the production of hyoid bone fracture. The reason for the absence of Simon’s bleeding in my study might be the small number of sample study or no convulsions occurred which is the mechanism for the production of Simon’s bleeding. Due to the convulsion

there is lateral extensive movements which rupture the branch of lumbar artery, this might not occurred so no bleeding into the anterior aspect of intervertebral disc.

The occurrence of bowel wall hemorrhage is due to the circulatory dysregulation, which is due to the altered gradient between the artery and veins. The bowel wall which showed hemorrhages are sent to the Institute of pathology and the presence of hemorrhages are confirmed histologically in my cases, and all the other disease which cause the hemorrhages on the bowel wall are excluded from my study, this shows that bowel wall hemorrhage can be found in cases of hanging which is antemortem in nature. This study showed significant results but still the number of samples in this study is less. In future the study should be conducted in large number of samples to get very highly significant results. Only few studies conducted till now on bowel wall hemorrhage and its correlation with the antemortem hanging.

Conclusion

CONCLUSION

This study shows that the bowel wall hemorrhage occur in cases of hanging of ante mortem in nature, which is correlated well with the hemorrhages around the ligature abrasion, which has a significant p-0.005 value. This study is done to show that even with absence of another characteristics vital sign, from the presence of bowel wall hemorrhage in hanging we can consider it as antemortem in nature. In my study even with the absence of ligature abrasion in two cases, there is presence of bowel wall hemorrhage which is confirmed histologically, this shows that even with absence of another vital sign we can prove the antemortem nature by the presence of bowel wall hemorrhage. It is not present in all the cases of hanging, but if it is present and other pathologies of bowel wall hemorrhage ruled out, it is considered as one of the important antemortem finding.

By excluding all the other pathology which produces hemorrhages on the bowel wall like DIC, septicemia, congenital or acquired bleeding disorder, bowel related surgeries in the previous, chronic intestinal diseases, trauma to the abdomen, hypothermia, putrefaction, the presence of bowel wall hemorrhage can be considered as one of the important vital sign to say the hanging as a antemortem one. But the absence of bowel wall hemorrhage in hanging cases cannot rule out the antemortem nature. Its presence is added as a

more value to the antemortem nature and when the other signs absent, the presence of bowel wall hemorrhage alone can be considered as a ante mortem finding if above said pathology are ruled out.

By concluding bowel wall hemorrhage is a valid antemortem sign of hanging. But it is not specific it can occur in other causes which should be excluded before taking it as antemortem sign. When the other antemortem sign is minimal or absent, bowel wall hemorrhage can be considered as the sign of antemortem nature.

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Annexures

COLOUR PLATES

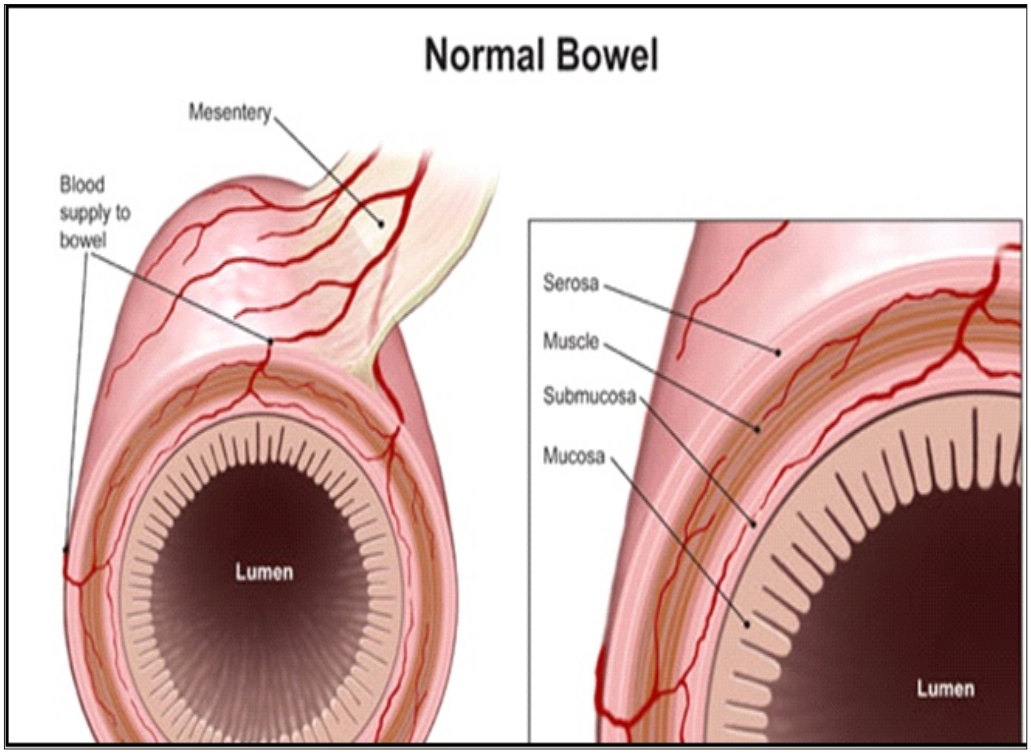


Fig 4. Anatomy of small bowel with vascular arrangements

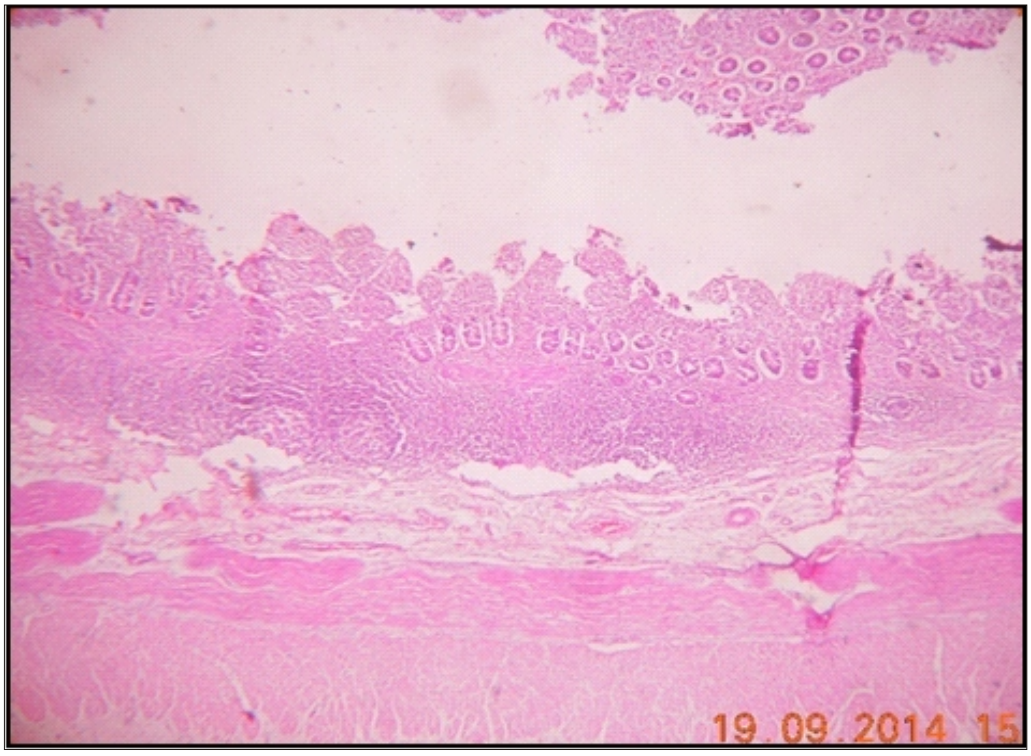


Fig 5. Normal histology of small bowe

Fig 6. Case of hanging with no ligature mark.

Fig 7. Presence of bowel wall hemorrhage in the absence of ligature mark.

Fig 8. Bluish discoloration of all the fingernails.

Fig 9. Case of hanging with no ligature mark.

Fig 10. Presence of bowel wall hemorrhage in the absence of ligature mark.

Fig 11. Bluish discoloration of the fingernails.

Fig 12. Case of hanging with faint ligature mark.

Fig 13. Presence of hemorrhage in duodenum in case of hanging with faint ligature mark.

Fig 14. Petechial hemorrhage in the anterior surface of lungs in a case with absent ligature abrasion.

Fig 15. Jejunum showing hemorrhage in hanging case.

Fig 16. Jejunum showing hemorrhage in hanging case.

Fig 17. Congestion of kidney in hanging case.

Fig 18. Oblique incomplete irregular reddish brown ligature abrasion.

Fig 19. Multiple petechial hemorrhage on the pericardial surface.

Fig 20. Multiple petechial hemorrhage on the anterior surfaces of lung.

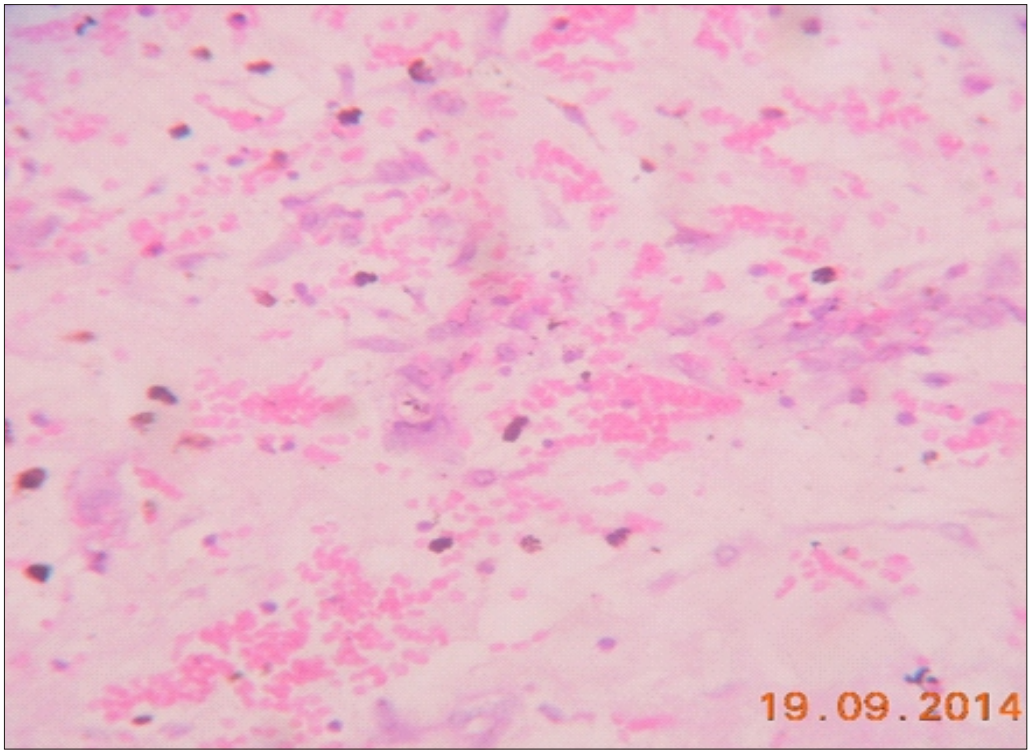


Fig 21. Histology of jejunum showing extravasation of RBC's on the serosa layer

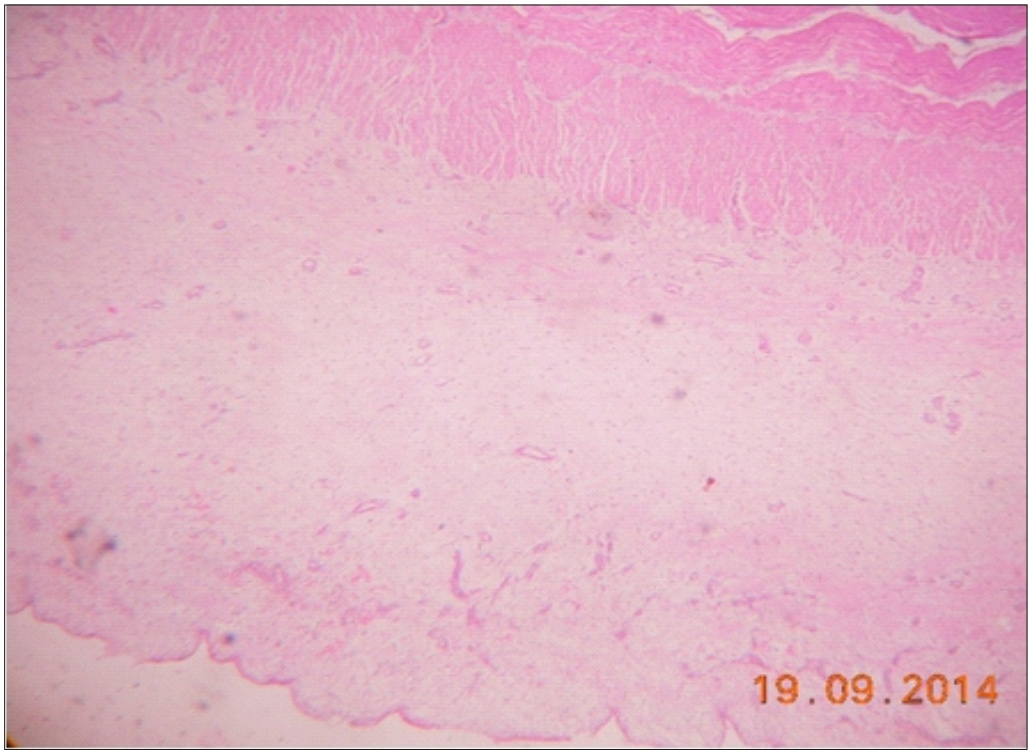
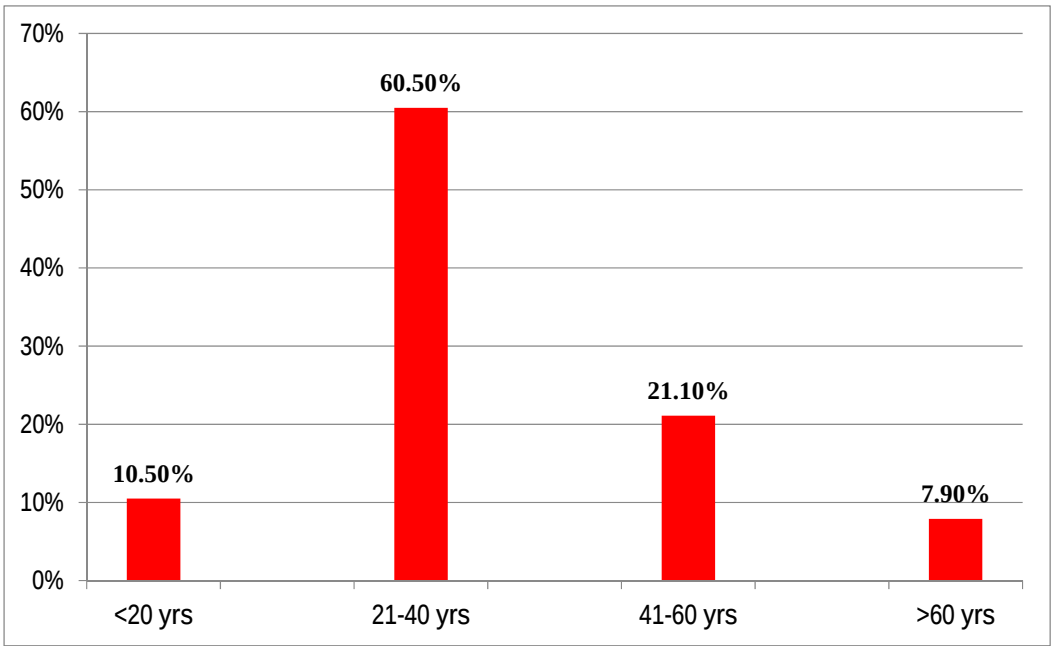


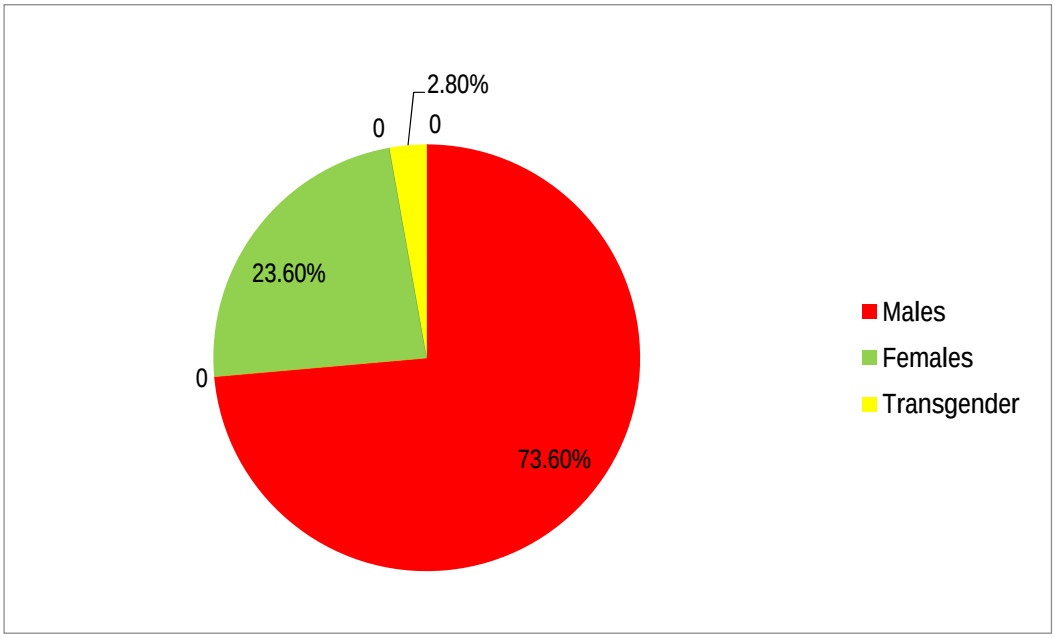
Fig 22.Histology of jejunum with mucosa, sub mucosa, muscularis layer normal but with edematous serosa layer

Graphs

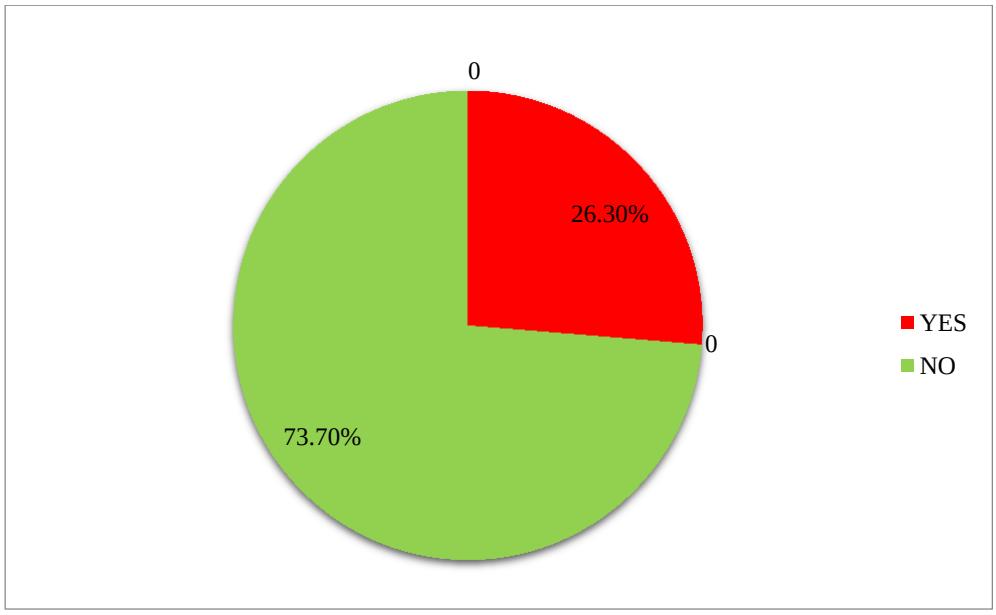
BAR DIAGRAM SHOWING AGE DISTRIBUTION OF STUDY POPULATION



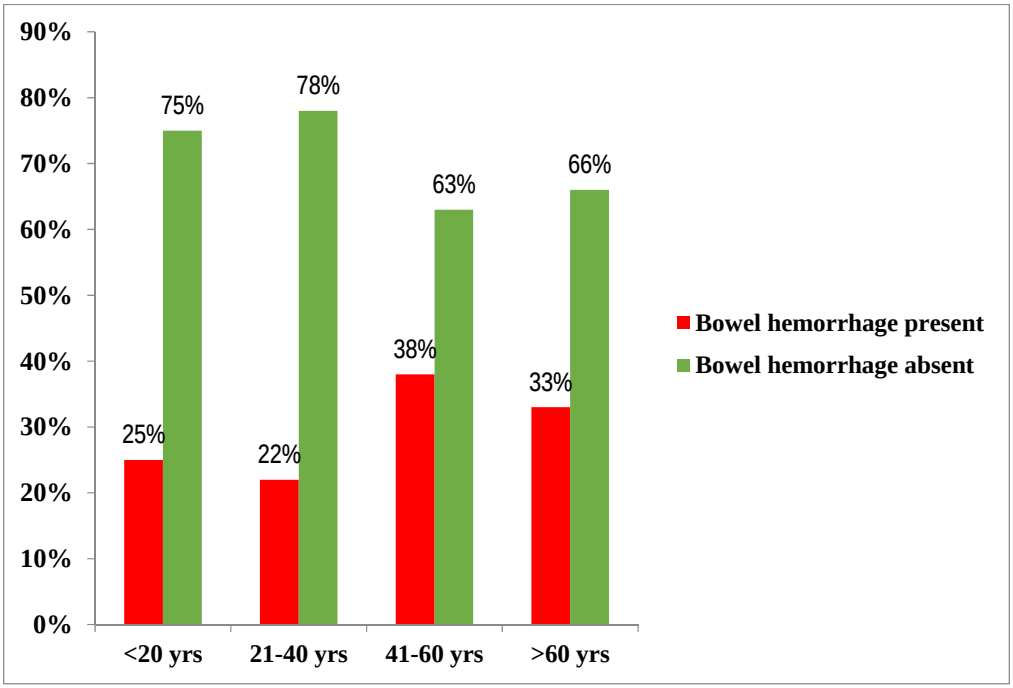
PIE CHART SHOWING SEX DISTRIBUTION OF STUDY POPULATION



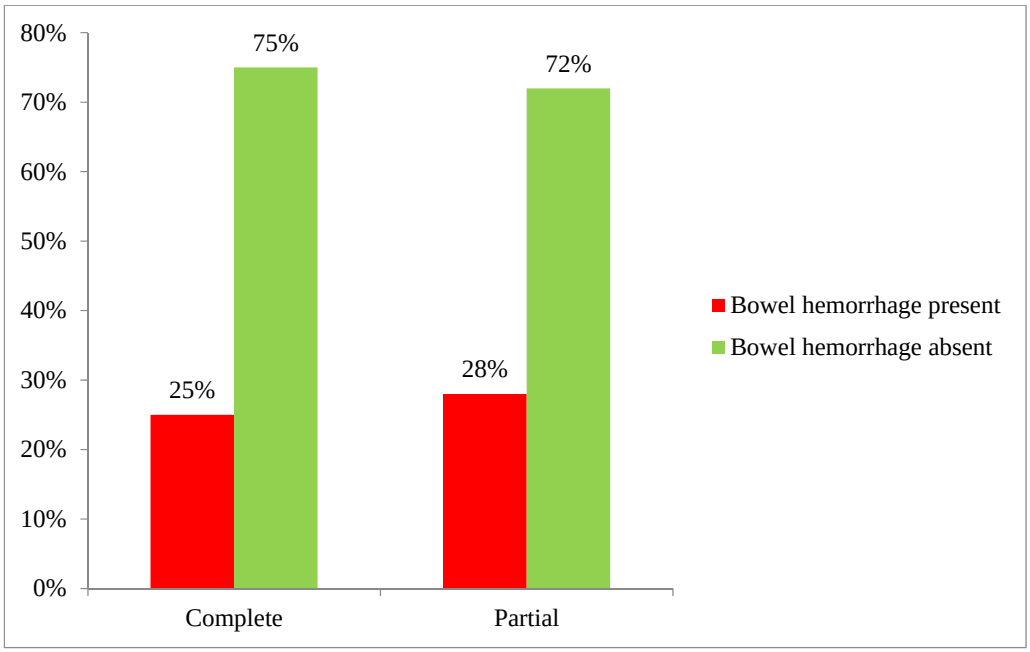
FREQUENCY OF BOWEL WALL HEMORRHAGE AMONG THE STUDY SUBJECTS



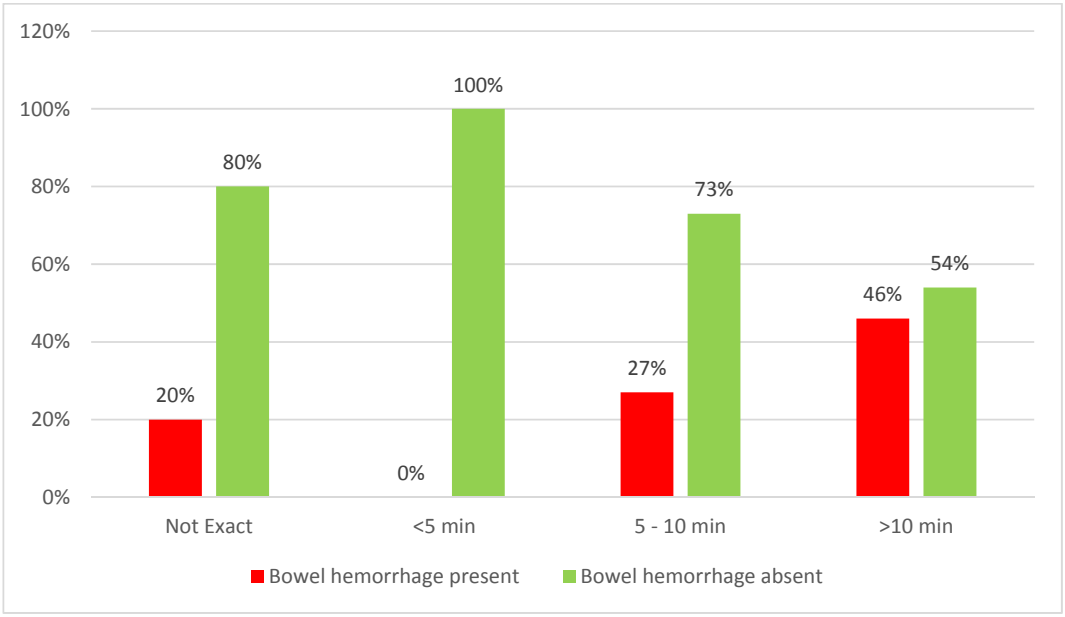
PRESENCE OF BOWEL WALL HEMORRHAGE IN DIFFERENT AGE GROUPS



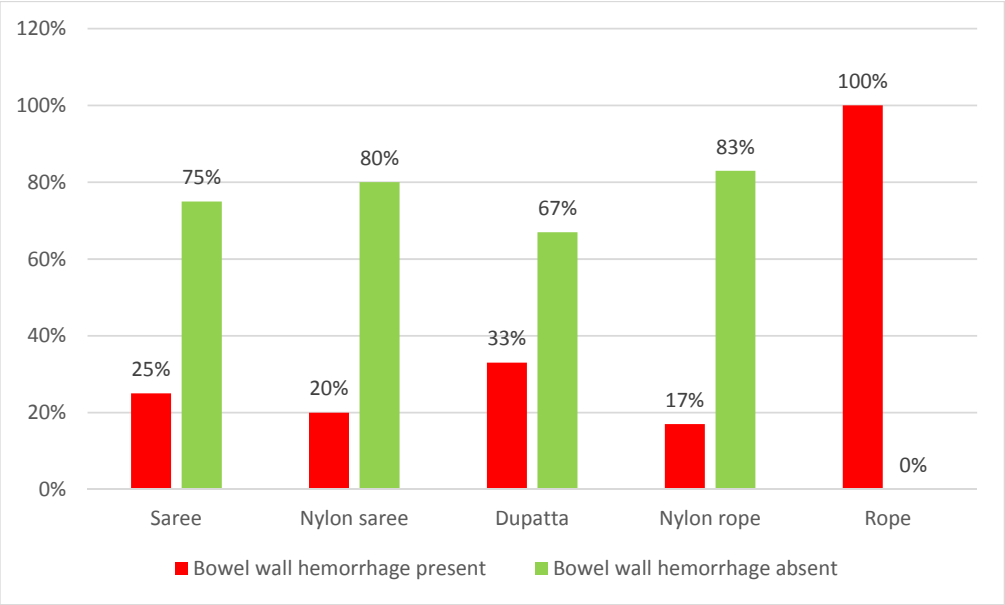
FREQUENCY OF BOWEL WALL HAEMORRHAGE WITH THE TYPE OF HANGING



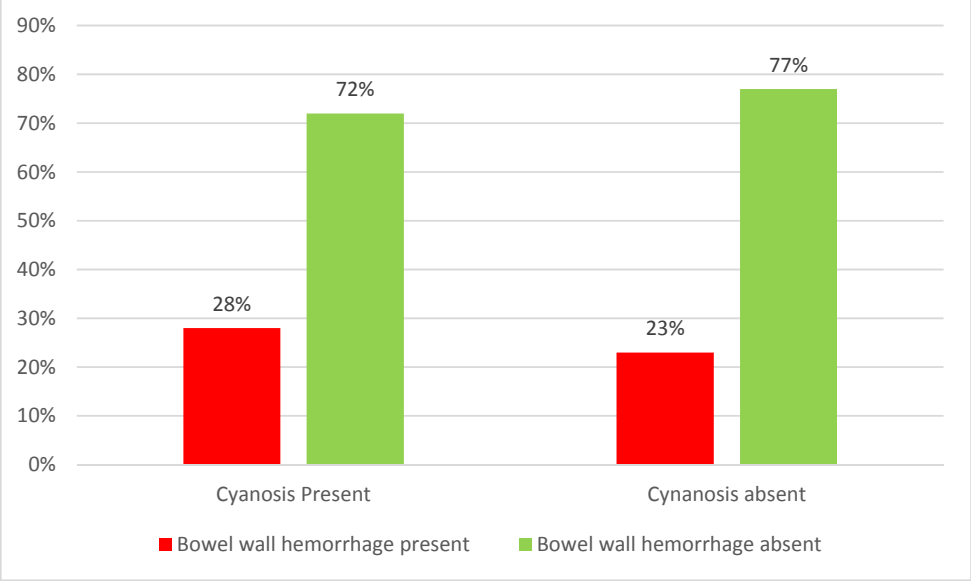
FREQUENCY OF BOWEL WALL HAEMORRHAGE WITH RESPECT TO DURATION OF HANGING



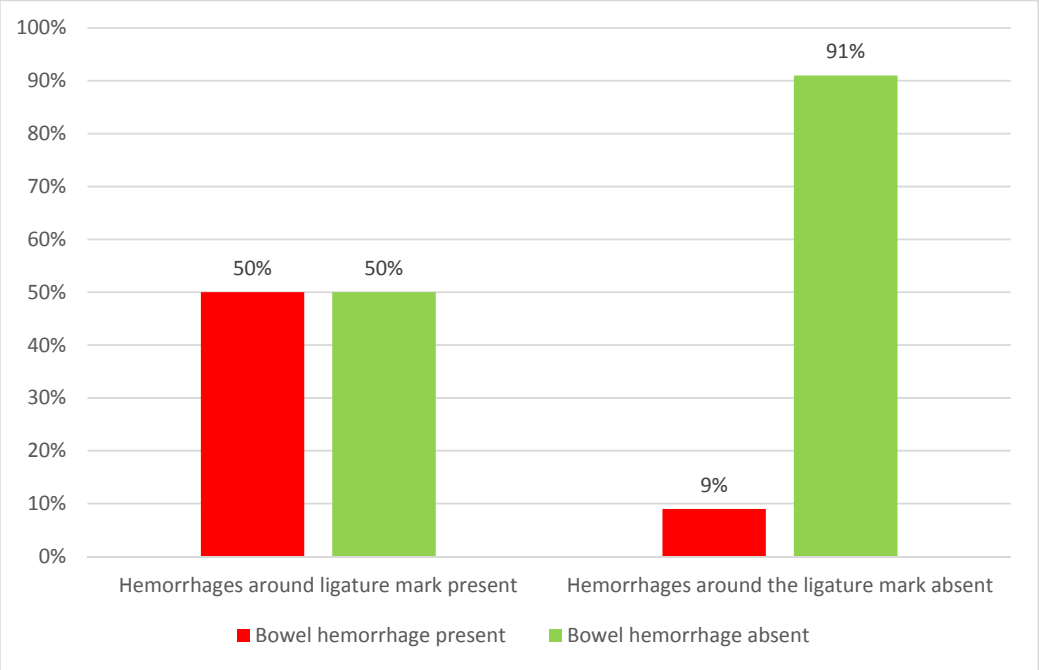
FREQUENCY OF BOWEL WALL HAEMORRHAGEWITH RESPECT TO MATERIAL USED FOR HANGING



CORRELATION BETWEEN BOWEL WALL HAEMORRHAGE AND CYANOSIS



CORRELATION BETWEEN BOWEL WALL HEMORRHAGES AND HEMORRHAGES AROUND THE LIGATURE ABRASION



Chi square test values

4-1 TABLE Critical Values of the χ^2 Distribution

	P									
df	0.995	0.975	0.9	0.5	0.1	0.05	0.025	0.01	0.005	df
1	.000	.000	0.016	0.455	2.706	3.841	5.024	6.635	7.879	1
2	0.010	0.051	0.211	1.386	4.605	5.991	7.378	9.210	10.597	2
3	0.072	0.216	0.584	2.366	6.251	7.815	9.348	11.345	12.838	3
4	0.207	0.484	1.064	3.357	7.779	9.488	11.143	13.277	14.860	4
5	0.412	0.831	1.610	4.351	9.236	11.070	12.832	15.086	16.750	5
6	0.676	1.237	2.204	5.348	10.645	12.592	14.449	16.812	18.548	6
7	0.989	1.690	2.833	6.346	12.017	14.067	16.013	18.475	20.278	7
8	1.344	2.180	3.490	7.344	13.362	15.507	17.535	20.090	21.955	8
9	1.735	2.700	4.168	8.343	14.684	16.919	19.023	21.666	23.589	9
10	2.156	3.247	4.865	9.342	15.987	18.307	20.483	23.209	25.188	10
11	2.603	3.816	5.578	10.341	17.275	19.675	21.920	24.725	26.757	11
12	3.074	4.404	6.304	11.340	18.549	21.026	23.337	26.217	28.300	12
13	3.565	5.009	7.042	12.340	19.812	22.362	24.736	27.688	29.819	13
14	4.075	5.629	7.790	13.339	21.064	23.685	26.119	29.141	31.319	14
15	4.601	6.262	8.547	14.339	22.307	24.996	27.488	30.578	32.801	15

Master Chart

MASTER CHART

BOWEL WALL HEMORRHAGE AND VARIOUS OTHER FACTORS IN THE STUDY GROUP

S. NO	AGE	SEX	WEIGHT	HEIGHT	TYPE OF HANGING	DURATION OF HANGING	PM INTERVAL IN HOURS	LIGATURE MATERIAL USED	LIGATURE MARK	HEMORRHAGES AROUND LIGATURE MARK	HYOID BONE FRACTURE	THYROID CARTILAGE INJURY	PETECHIAE PRESENT IN	CYANOSIS	HEMORRHAGES ON INTESTINES	SIMONS BLEEDING	PRE EXISTING DISEASE
1	42	male	76	176	partial	>10 mins	11	saree	present	present	---	---	heart and lungs	present	patchy hemorrhages on the serosal layer of jejunum	---	---
2	60	male	65	165	complete	>10 mins	9	saree	present	present	---	---	lungs	absent	patchy hemorrhages on the serosal layer of jejunum	---	carcinoma of tongue
3	90	male	60	164	partial	>10 mins	10	lungi	present	present	---	---	heart and lungs	present	patchy hemorrhages on the serosal layer of jejunum	---	diabetes
4	36	male	73	168	partial	<10 mins	27	nylon saree	present	present	---	---	heart and lungs	present	patchy hemorrhages on the serosal layer of duodenum	---	---
5	29	female	48	160	complete	>10 mins	31	saree	faint mark	present	---	---	lungs	present	patchy hemorrhages on the serosal layer of jejunum	---	---
6	36	male	75	172	partial	<10 mins	25	saree	no mark	no	---	---	heart and lungs	present	patchy hemorrhages on the serosal layer of jejunum	---	---
7	42	male	74	160	partial	not known	8	duppata	present	present	---	---	lungs	absent	patchy hemorrhages on the serosal layer of duodenum	---	---
8	34	female	54	156	complete	<10 mins	12	nylon rope	present	present	---	---	heart and lungs	absent	patchy hemorrhages on the serosal layer of duodenum	---	---
9	18	female	42	160	complete	>10 mins	33	duppata	present	present	---	---	lungs	present	patchy hemorrhages on the serosal layer of ileum	---	---
10	27	male	66	166	complete	<10 mins	13	saree	no mark	no	---	---	--	present	patchy hemorrhages on the serosal layer of jejunum	---	---